# ANNUAL SCIENTIFIC REPORT

1978-79

TEA RESEARCH ASSOCIATION CALCUTTA

*Our Cover*

Different Methods of Plucking

# TEA RESEARCH ASSOCIATION

# *Annual Scientific Report*

*The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientitic Report (Part II) for the period 1st April, 1978 to 31st March, 1979. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T. R. A., Calcutta.*

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# Contents

# Director's Report

*1st April, 1978 to 31st March, 1979*

Scientific progress of an industrial research institute like Tocklai depends upon the support it receives from the industry and the availability to it of the resources of personnel, their quality, physical facilities and scientific equipment. Planning and organisation to marshal these resources in the best possible manner is a prerequisite for orderly progress of modern research. In this note I shall attempt to bring to your notice these items as an introduction to the main scientific report of Tocklai.

**TRA Membership**

Continued support of the industry to our institute was evident from further increase in membership to include some 88% of the total crop in N.E. India. During 1977-78, the Tea Research Association added 17 members to its family, raising its membership strength to 788 tea estates. Consultancy firms were inducted into membership in a new category of Associate Members. Another new category was of the new estates which had not started production as yet.

**Liasion with Industry**

Tocklai's liasion with the industry is very close and is the backbone of its effective services. It enmeshes with almost the entire functioning of Tocklai, ranging from finance & control to technology transfer and services.

Effectiveness of Tocklai's R & D efforts is evident by increasing productivity of its members; the difference in the hectare yield of member tea estates and non-member tea estates has widened this year to almost 50%, yields being 1626 and 1070 kg per hectare respectively.

**Personnel**

On 31st March 1979, Tocklai had a total strength of 47 officers and 568 staff members, of which 41 were specialist officers and 154 research assistants and research fellows. The experimental estate employes at Borbhetta and Tocklai Division additionally 604 persons. During the year five officers, one each in Plant Breeding, Biochemistry, Research Engineering, Advisory and Accounts have joined in addition to 17 research assistants. Two officers left the service of the Association and two officers retired while among staff members five retired and nineteen resigned.

Quality of a research institute is reflected by the quality of its scientific manpower. The Doctorate and Master's degree holders amongst its scientific staff have increased to 76. We have further built upon this basic strength. In order to improve the utilisation of our resources for achievement of TRA's objectives, two senior officers attended courses on Management of R & D in top level management institutes. Two research assistants were sent for training to equip themselves with higher standard of research ability in their respective subjects. Two officers were sent to visit Tea Research Institutes in Indonesia, and Malaysia and attended a seminar on tea in Indonesia.

**Sub-stations**

A major organisational decision has been taken for setting up full fledged sub-stations/regional centres for better technology transfer and more intensive study of regional problems. Already one major sub-station at Nagrakata is being commissioned for adapting technology to local problems and to transfer the existing and new technology more effectively to the tea industry. Implementation of plans for developing the Cachar Advisory Centre into a Regional Sub-station has been deferred to the next year (1979-80) and of North Bank to the year after (1980-81).

The strength of other Advisory Centres has been improved by adding more Advisory Officers for estates visits during the year.

**Physical facilities**

On campus housing facilities have been expanded. Staff housing construction awaits transfer of Tocklai Tea Estate to TRA, for availability of housing site to accommodate all categories of staff. Construction work at Nagrakata has been assumed in full swing for the development of the sub-station. Another soil testing laboratory is in the planning stage at Cachar to accommodate the growing need of the planters for soil tests. The master plan for development of Silcoorie sub-station has been prepared and sent for approval of TRA. Some urgent construction works for offices, housing etc. which have been approved, are in progress in this and other regional centres. The master plan for the sub-stations will be implemented in phases in the forthcoming years.

During the year, several items of major equipment at a total cost of Rs. 8.26 lakhs were added to the existing laboratory facilities. These equipments included Spectrophotometer, Gas Chromotograph, Infrared Gas Analyser, Technicon Autoanalyser, Binocular Microscope, Olympus Trinocular Microscope, Drip Irrigation Equipments, Portable Area Meter, Autoporometer, Quantum Light Meter, Plant Water Satus Console and two Burkard Spore Traps.

**R & D Planning**

For the last few years, Tocklai has instituted a system of drawing up long and short term plans and introduced project budgeting concept. This has been continued to be improved over the years and is now forming the base of planning for manpower, building and equipment.

We have formulated a 5 year programme of work last year. This year for the first time, Tocklai brought out the Five Year Rolling Plan, which is a projection of the activities for an additional period beyond the Five Year Plan period i.e. from 1979-80 upto 1983-84. This rolling plan describes the plan perspectives for the period 1979-80 to 1983-84 of 25 Research Projects and the All India Coordinated Projects where Tea Research Association will participate. Budget estimates for 1979-80, projected estimates for the other years of Rolling plan period, the Plan and Non-Plan break-down for the estimates, project/infrastructure wise are given in this Rolling plan document. Since most of the biological research projects of Tocklai Experimental Station are long term and continuing in nature, the rolling plan will be of great help for recasting the research activities each year.

The annual research plan and project budget for 1979-80 was prepared which is the second exercise of its kind at Tocklai. It gives detailed experimentwise break down of the budgeted expenditures of Tocklai and out-stations along with the extent of research manpower involvement in each project. It will help in monitoring the progress of each project from time to time.

Long term plans for manpower requirements, laboratory space and equipment have been prepared. A master plan is now under way.

Interaction with the Planning Division, C.S.I.R. and the Department of Science and Technology has been maintained for supplying information pertaining to the R&D activities of Tocklai. Foreign exchange budget for 1979-80 for the Tea Research Association was prepared and submitted to the Council of Scientific and Industrial Research.

The concept of PERT planning has been introduced in planning physical facilities. One of the major problems has been the delay in recruitment of scientific personal. A PERT plan was prepared with detailed break down of activities for completing the recruitment in minimum possible time. Similarly PERT charts were prepared to complete preparations for Tocklai Biennial Conference in time, as well as for construction of new laboratory buildings. Efforts are now under way for introducing this system in selected projects for planned systematic completion of the jobs.

**Collaboration in research**

Tocklai has a long history of collaborative research which has been recently built upon. From 1962 to 1976, the station financed a research project on Chemistry of tea at Sheffield University in the U.K. where its scientists went for work. Physiological aspects of the tea plant were studied by Tocklai scientists in collaboration with Cambridge University scientists from 1961 to 1975. Co-operation between UPASI and Tocklai dates back to 1925 when the first scientific officer of UPASI was trained at Tocklai for one year, before taking up his assignment. Collaborative and complementary research projects are now being drawn up between UPASI and TRA where three joint consultation panels - on production, plant protection and tea technology aspects have been formed. The Tea Board is financing a pilot plant on instant tea at Tocklai in collaboration with Calcutta University. For the last several years, India-Srilanka joint panels have identified research projects for collaborative and complementary R & D efforts between Tocklai, UPASI, TRI Srilanka, Packaging Research Institute, which are sponsored by the Tea Boards of India and Srilanka, respectively. We have a current research project with Unlever's Colworth laboratory to study the aroma constituents of black tea as well as pigment constituents of CTC and Orthodox teas in relation to pigment profile.

Tocklai has entered into research collaboration with sister laboratories in C.S.I.R. for All India Coordinated Projects and other projects of national importance in the areas of interest to the tea industry and which are part of our approved Five Year Programme of work. We are accordingly carrying out researches in (1) Chemistry and pharmacology of tea with Central Drug Research Institute, Lucknow; (2) Development of tea machinery *viz* (a) material for replacement of present CTC roller (b) fluidised bed coal heater for the present tea drier, (c) fluidised bed drier, (d) tea plucking machine, (e) sprayer with pulse engine and (f) studying orthodox rolling machine and withering system with Central Mechanical Engineering Research Institute, Durgapur; (3) Development of non-conventional tea beverages with Central Food Technological Research Institute, Mysore; and (4) Biological evaluation of pesticides with Industrial Toxicological Research Centre, Lucknow. Other projects *viz.* (5) Utilisation of byproducts of tea with Regional Research Laboratory, Jorhat and Central Leather Research Institute Madras, (6) Aerobiological survey with Centre of Biochemicals, New Delhi and National Botanical Research Institute Lucknow, (7) Development of agrotechniques for some of the economic, medicinal and aromatic plants with Central Institute of Medicinal & Aromatic Plants, Lucknow, will soon be finalised. A project of national importance on (8) Biological control of pests, is coordinated by a Tocklai scientist. Work on (9) Electronic/electrostatic stalk separator will be taken up with National Physical Laboratory New Delhi and (10) Tissue culture work is with National Chemical Laboratory Pune. Collaborative projects are under way, (11) to study the Application of certain mathematical techniques for forecasting of crop and cultural operations in relation to weather factors with the facility of the Govt. Engineering College North Bengal University, (12) for Ergonomic study of tea plucking with Department of Ergonomics & Physiology, Calcutta University and (13) for the Use of ionising

radiation for tea breeding and plant physiological work with Bhaba Atomic Energy Research Centre.

**Technical assistance**

The U.N.D.P. financed project on drainage is progressing. Next year one specialist and a research assistant are scheduled to go to Netherlands for higher studies with F.A.O. fellowships under this scheme. Another scientist will visit several centres in the U.K., Europe and U.S.A. in this context.

The plan proposal submitted to the Overseas Development Ministry, U.K., estimated to cost approximately £ 1.7 million, has drawn their keen attention for strengthening research at Tocklai through twinning arrangements with counterpart research institution in the U.K. Several British experts have visited to assess Tocklai's needs to take up further collaborative projects. They are believed to have strongly recommended that ODM may provide assistance to Tocklai through (i) provision of sophisticated equipments not available in India, (ii) consultancy visits of experts, (iii) training of research personnel in the U.K., and (iv) other resources to build up Tocklai's capability.

**In service Refresher/Training courses**

A very important aspect of technology transfer is to bring tea planters and their staff *au fait* with the latest development in technology through various short-term refresher/inservice courses at Tocklai. The one year training course on tea culture for building up junior tea garden executives has also continued during the year. Of the short term refresher courses offered to the planters were two 5-day courses in Field Drainage, three 3-day courses in Tea Economics, two 3-day Field Management courses and one 1-day orientation course in the Methods of Work Study, apart from two 4 week Vegetative propagation training courses for supervisory staff for the members of the north-east Indian tea industry.

**Instant Tea Project**

Tocklai continued its experiments in a pilot plant installed at Tocklai and sponsored by the Tea Board. Engineering and other data were generated to upscale the method of instant tea production. Under this project a hot soluble instant tea which is as good liquoring as orthodox teas of second flush, was produced for the first time. Investigations are now under way to stabilise the quality and reduce the costs to make it a commercially feasible process.

**Research results**

Individual departments have reported about the progress of various projects in the succeedings chapters. A feature of this report is a summary of the work done for 14 years in tea chemistry at Sheffield University, on behalf of the Tea Research Association. This and a report on the Instant Tea Pilot Plant are given after the departmental progress reports.

Since the last report, we have followed a system of highlighting individual department's work in the beginning of each section and then giving details of research findings which the readers will find most interesting.

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( N.K. Jain )
Director

**Liaison with the Industry**

Tocklai has a close liaison with the tea industry of North East India which it has served for 79 years. TRA's Council of Management which is composed of elected members of the industry and CSIR nominees, is responsible for finance and control of the Station. For effective technology transfer and providing services, Tocklai interacts very closely with individual units of the industry. These points of interaction of Tocklai with the industry are listed below :

1. **Finance & Control :** It is effected by the Council of Management which is assisted by a number of Committees :

**Council of Management**

a. Executive-committee

b. Technical committees
   i) Engineering sub-committee
   ii) Agricultural sub-committee
   iii) Economic Advisory sub-committee
   iv) Agricultural Chemicals Advisory sub-committee
   v) Tea Tasting Advisory Panels :
      Tocklai
      Calcutta
      Gauhati
      London

c. Scientific Advisory Committee *in lieu* of London Scientific committee since 1976.

2. **Technology Transfer :** This is the main activity of Tocklai. Transfer of technology takes place at different levels of plantation community by the following methods :

a. **Group Meetings**
   Tocklai Biennial Conference
   Biennial Joint Area Scientific Meet
   Area Scientific Committee Meetings
   (quarterly meets of each of the 9 committees)
   Seminars
   Symposia
   Tea Tasting Sessions
   Special Seminars

b. **Individual Visits**
   Advisory routine visits
   Advisory special calls
   Specialist visits

c. **Training Courses and their annual frequency**
   Field Management : 2
   Drainage : 3
   Economics : 3
   Manufacture ( due to be revived next year)
   Work Study : 2
   Vegetative Propagation : 2
   One year course for
   junior executives : 1

d. **Publications**
   Annual Scientific Report

   Two and A Bud (Half-yearly journal)
   Tea Encyclopaedia
   Memoranda (monographs)
   Conference Proceedings
   Advisory Bulletins
   Special Bulletins
   Occassional Papers
   Advisory Leaflets

e. **Others**
   Borbhetta Experimental Station visits
   Clonal Proving Statiton/plots
   Operational Research plots
   Estate trials/experiments
   Estate R & D scheme
   Technological Museum
   Correspondence

3. **Services :** Tocklai offers a number of services to its members, free of charge.

a. **Usual Services**
   Soil testing
   Pesticide bioassay
   Eelworm assessment
   Moisture metre calibration

   Identification of
      Pests
      Diseases
      Weeds
   Age diagonosis
   Tea tasting
   Estate visit reports

b. **Special Services**
   Machine Design
   High Yielding varieties
      Clones
      Seed stocks
   Estate Project reports
   Techno Economic surveys
   District Selection scheme
   Estate Clone certification
   Trouble shooting advice on manufacture

## Senior Staff

On the 31st March 1979, the Senior Staff consisted of :

Director
Dr. N.K. Jain, M.Sc.Ag. (B.H.U.), Ph.D. (Illinois)

Deputy Director
Dr. P.C. Sharma, M.Sc. (B.H.U.), Ph.D (London), F.L.S.

Adviser, T.R.A.
Dr. D.N. Barua, B.Sc. (Calcutta), Ph.D. (Cantab)

Cost Adviser
Mr. N.S. Venkatakrishnan, M.A. (Madras), LL.B., F.I.C.W.A.

## Directorate

*Administration :*
Administrative Officer
Group Captain K.R. Gopalan (Retd.)

Assistant Administ ative Officer
Mr. B.S. Kotoky, B.A., LL.B. (Dibrugarh)

*Accounts :*
Accounts Officer : VACANT

Assistant Accounts Officer
Mr. H.N. Sinha, M.Com.

*Maintenance :*
Officiating Station Engineer
Dr. H.K. Barua, M.Tech. (Structural Engg.), Ph.D. (Kharagpur)

*Medical :*
Medical Officer
Dr. (Major) S.W. Rohman, M.B.B.S.

*Library & Publication :*
Librarian and Assistant Publication and Information Officer
Mr. J.N. Sharma, M.A. (Gauhati)

*Planning :*
Assistant Planning Officer
Mr. S. Acharya, B.Sc. (Agril Engg. & Tech.), M. Tech. (Ind. Mgt.) (IIT Kharagpur)

*Advisory :*
Head of Department

Dr. T.K. Ghosh, B.Sc. (Patna), Ph.D. (Cornell), Assoc. I.A.R.I.

Advisory Officer
Dr. D.N. Chakrabarty, B.Sc. Ag. (B.H.U.), Ph.D. (Agronomy) (Moscow)

Assistant Advisory Officer
Dr. S. Basu, B.Sc. (Calcutta), M.Sc. Ag. (Calcutta), Ph.D. (Calcutta)

*Upper Assam :*
Advisory Officer
Mr. J. Chakravartee, M.Sc. Ag. (Gauhati)

*North Bank :*
Advisory Officers
Mr. B.C. Barbora, M.Sc.Ag. (I.A.R.I.)
Mr. B. Borthakur, M.Sc.Ag. (Gauhati)

*Cachar :*
Advisory Officer
Mr. S.K. Sarkar, B.Sc. (Calcutta), B.Sc.Ag. (B.H.U.)

*Tripura :*
Assistant Advisory Officer
Mr. S.C. Dey

*Agronomy :*
Head of Department :
Dr. F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist (Weed Control)
Dr. V.S. Rao, M.Sc. Ag. (Osmania), Ph.D (Cornell)

Estate Manager
Mr. A. Sahney, B.A. (Delhi)

*Soils & Meteorology :*
Head of Department :
Mr. S.K. Dey, B.Sc. (Calcutta), Assoc., I.A.R.I.

Second Soil Scientist
Dr. B. Singh, B.Tech. (Pant Nagar), M.Tech. (I.A.R.I.), Ph.D. (Newcastle)

Assistant Soil Scientist
Mr. N.G. Bhattacharjee, B.Sc. (Calcutta)
Assistant Soil Scientist —located at Nagrakata Sub-station.

*Botany :*
Head of Department :
Dr. H.P. Bezbaruah, M.Sc., Ph.D. (Gauhati)

Plant Physiologist
Dr. P.N. Rustagi, B.Sc. (Hons), M.Sc., Ph.D. (Delhi)

Second Plant Breeder
Dr. I.D. Singh, M.Sc. Ag. (Agra), M.Sc. (Guelph), Ph.D, (Georgia)

Assistant Plant Physiologists
Mr. B.N. Gogoi, B.Sc. (Gauhati)
Dr. L. Manivel, M.Sc.Ag. (Madras), Ph.D. (California)

*Entomology :*
Head of Department :
Dr. B. Banerjee, M.Sc. (Calcutta), M.S. (S. Illinois), Ph.D. (London), F.A.Z., F.R.E.S. (London)
Assistant Entomologist — located at Nagrakata Sub-station.

*Mycology :*
Head of Department :
Dr. G. Satyanarayana, B.Sc. (Hons) (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.

C.S.I.R. Pool Officer
Dr. M.N. Venkataramanan, M.Sc., Ph.D. (Madras)

*Biochemistry :*
Assistant Biochemist (Officer-in-charge)
Dr. M.R. Ullah, M.Sc., Ph.D. (Gauhati)

Assistant Biochemist
Dr. P.K. Mahanta, M.Sc.,(Gauhati), Ph.D.(Gauhati) located at C.D.R.I., Lucknow.

*Tea Tasting :*
Tea Taster
Mr. R.P. Basu located at Nagrakata Sub-station
Second Tea Taster
Mr. A.K. Das, B.A. (Gauhati)

*Engineering Research & Development :*
Head of Department :
Mr. T.C. Baruah, B.Sc. (Hons). (Gauhati), B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Manchester)
Assistant Research Engineer
Mr. B.N.S. Rao, B.E., M.Tech. (IIT, Madras)

*Statistics :*
Head of Department :
Mr. A.K. Biswas, M.Sc. (Gauhati)

*Agricultural Economics :*
Agricultural Economist
Dr. R.C. Awasthi, M.Com., LL.B., Ph.D. (Agra).

**Nagrakata Sub-Station**
*West Bengal*

Deputy Director
Mr. S. Basu, B.Sc.Ag. (Hons). (Delhi), Assoc. I.A.R.I.

*Advisory :*
Advisory Officer, Dooars
Mr. B.C. Phukan, B.Sc.Ag. (Gauhati), A.I.F.C.

Assistant Advisory Officer, Dooars
Mr. R. Das Gupta, B.Sc.Ag. (Ranchi), M.Sc. Ag. (Bhagalpur)

Assistant Advisory Officer, Western Dooars & Terai
Mr. A.K. Bhargava. M.Sc. (Agra)

Advisory Officer, Darjeeling
Mr. R. Padmanaban, B.Sc. Ag. (Madras)

*Soils & Meteorology :*
Assistant Soil Scientist
Mr. A.K. Sengupta, B.Sc. (Hons). (Calcutta)

*Entomology :*
Assistant Entomologist
Mr. N.S. Sengupta, B.Sc.Ag. (Dacca)

*Tea Tasting :*
Tea Taster
Mr. R.P. Basu

## SENIOR STAFF MATTERS

**Appointment**

Dr. P.C. Sharma, Senior Advisory Officer joined as Deputy Director on 1st April, 1978.

Mr. B.N.S. Rao joined as Assistant Research Engineer on 1st June, 1978.

Dr. I.D. Singh joined as Second Plant Breeder on 28th June, 1978.

Mr. A.K. Bhargava joined as Assistant Advisory Officer on 1st July, 1978.

Mr. H.N. Sinha joined as Assistant Accounts Officer on 12th September, 1978.

Dr. P.K. Mahanta joined as Assistant Biochemist in Tea Chemistry Scheme at CDRI, Lucknow on 28th November, 1978.

Mr. S. Basu, Head, Advisory Department joined as Deputy Director on 1st January, 1979 at Nagrakata Sub-Station.

Dr. T.K. Ghosh, Advisory Officer joined as Head, Advisory Department on 1st January, 1979.

Dr. H.K. Barua joined as Officiating Station Engineer on 1st January, 1979.

**Transfer**

Mr. R. Das Gupta, Assistant Advisory Officer has been transferred to Terai & Western Dooars Advisory Branch in January, 1979.

**Retirement**

Mr. H. Mitra, Advisory Officer, West Bengal Advisory Department retired on 26th August, 1978.

Mr. G.B. Singh, Station Engineer retired on 31st December, 1978.

**Resignation**

Mr. S. Mazumdar, Accounts Officer resigned from Association's service on 22nd February 1979.

## TRAINING & COURSES

**One year Training Course for Inservice Candidates**

1st course — which began on 1.2.78 was completed on 31.1.79 with 8 successful trainees

2nd course — from 1.2.79 to 31.1.80 — 15 inservice trainees have been admitted

**Vegetative Propagation Training Course for supervisors**

1st course from 1.5.78 to 15.6.78 — 10 trainees

2nd course from 1.10.78 to 15.11.78 — 10 trainees

**Surveying & Drainage Courses**

1st course from 18.12.78 to 22.12.78 — 22 members attended

2nd course from 8.1.79 to 12.1.79 — 24 members attended

3rd course from 22.1.79 to 26.1.79 — 23 members attended

**Field Management Course**

1st course from 11.9.78. to 14.9.78 — 24 members attended

2nd course from 18.9.78 to 21.9.78 — 26 members attended

**Planter's Course on Tea Economics**

1st course from 3.10.78 to 5.10.78 — 17 members attended

2nd course from 16.10.78 to 18.10.78 — 17 members attended.

3rd course from 23.10.78 to 25.10.78 — 32 members attended.

## VISITS

The Director attended the Biological Coordination Council meeting held at Delhi on 20.4.78; Council of Management & Executive Committee meeting held at Calcutta on 22.5.78; CSIR Director's Conference held at Mysore on 2.6.78 and 3.6.78; Engineering Sub Committee meeting held at Calcutta on 14.6.78; Economic Advisory Committee meeting held at Calcutta on 15.6.78; CSIR Governing Body meeting held at New Delhi on 19.6.78; Plantation Group of Ministry of Commerce meet at New Delhi on 20.6.78; CSIR Rural Technology Transfer meeting held at New Delhi on 23.6.78; Research Liasion Committee meeting of the Tea Board held at Nagrakata on 28.6.78; Shanti Swaroop Bhatnagar Award Committee meeting of CSIR held at New Delhi on 7.9.78; UPASI Scientific Conference & AGM held at Coonoor on 11.9.78 & 12.9.78; Executive Committee meeting held at Calcutta on 16.11.78; Agricultural Sub Committee meeting held at Calcutta on 16.11.78; Engineering Sub Committee meeting held at Calcutta on 17.11.78; Annual General meeting of TRA held at Calcutta on 27.12.78; Weed Science Society of India meeting held at Parbhani on 29.1.79. & 30.1.79 also visited BARC Bombay and NCL Poona; Executive Committee meeting of TRA held at Calcutta on 15.3.79; Council of Management meeting of TRA held at Calcutta on 16.3.79 and R & D Management Course at Staff College Hyderabad from 26.3.79 to 30.3.79.

**Group visits were made to the following places**

Jalpaiguri to attend the TRA meeting on Green Tea Manufacture from 30.6.78 to 4.7.78 by Dr. P.C. Sharma and Mr. A. K. Das.

Coonoor to attend the UPASI Scientific Conference & AGM from 11.9.78 to 12.9.78 by Dr. N.K. Jain, Mr. T.C. Baruah, Dr. M.R. Ullah and Mr. R.P. Basu.

Darjeeling to attend A.S.C. Seminar "Operation 15 quintals" by Dr. N.K. Jain, Dr. D.N. Barua, Mr. B. N.S. Rao, Mr. R. Padmanaban, Mr. S.K. Sarkar, Mr. B C. Phukan, Mr. R.P. Basu, Mr. R. Dasgupta, from 13.9.78 to 17.9.78.

Indonesia & Malaysia to study the tea research and tea industry and also presented a paper on 'Tea Industry in North-East India' at Tea Symposium II from 16.10.78 to 30.10.78 by Dr. H.P. Bezbaruah and Mr. B.C. Barbora.

New Delhi to attend the Potash Symposium from 16.11.78 to 17.11.78 by Dr. F. Rahman and Mr. S.K. Dey.

Calcutta to attend the Agricultural Sub-committee meeting from 15.11.78 to 16.11.78 by Dr. N.K. Jain and Dr. F. Rahman.

Calcutta to attend the AGM of TRA on 27.12.78 by Dr. N.K. Jain and Dr. F. Rahman.

Delhi to attend a Symposium on Plant & Animal Genetic Resources and present two papers on 'Tea germplasm' from 28.12.78 to 30.12.78 by Dr. H.P. Bez-Baruah and Dr. I.D. Singh.

Himachal Pradesh as TRA delegates from 18.1.79 to 22.1.79 by Dr. F. Rahman & Mr. B. Sarronwala.

Calcutta to attend a Workshop on patents-return organised by the CSIR from 28.1.79 to 1.2.79 by Mr. B.N.S. Rao & Mr. M.N. Gogoi.

Parbhani (Maharashtra) to attend the Weed Science Conference from 29.1.79 to 31.1.79 by Dr. N.K. Jain, Dr. F. Rahman, Dr. V.S. Rao and Mr. R. Padmanaban.

Kenya, Malawi & Mauritius to study the advances in tea research and the industry in general from 11.3.79 to 31.3.79 by Dr. F. Rahman and Mr. S.K. Sarkar.

Hyderabad to attend the R & D Management Course at Staff College from 26.3.79 to 30.3.79 by Dr. N.K. Jain and Dr. B. Banerjee.

**Individual Visits**

Dr. D.N. Barua attended the Industry Seminar at Darjeeling from 13.9.78 to 17.9.78.

Dr. G. Satyanarayana attended Microbiology Conference at Baroda from 9.11.78 to 13.11.78 and visited B.A.R.C., Bombay from 14.11.78 to 16.11.78.

Dr. B. Singh visited Water Technology Centre at Delhi from 26.12.78 to 28.12.78; Haryana Agricultural University, Hissar from 29.12.78 to 2.1.79 and Soils & Water Conservation Research and Training Centre at Dehradun from 3.1.79 to 7.1.79.

Mr. T.C. Baruah attended Engineering Sub-committee meeting at Calcutta on 9.9.78; and visited Port Engineering Works, Howrah to see the porgress of works on cutter attachment on 16.9.78.

Mr. A.K. Biswas attended Ag-Economics Advisory Committee meeting at Calcutta from 14.6.78 to 15.6.78 and visited Indian Statistical Institute and Regional Computer Centre at Calcutta from 12. 11.78 to 15.11.78.

Dr. R.C. Awasthi visited Poona to deliver a talk on Tea Finance in Agricultural Banking, Reserve Bank of India in July '78; Tea Seminar at Darjeeling in May '78 and attended the Programme on Cost Control organised by Institute of Productivity at Lucknow in September '78.

Mr. A.K. Das visited Calcutta to attend the Refresher Course from 17.12.78 to 30.12.78.

Mr. A. Sahney visited Calcutta twice for script and editing of the film prepared by Tocklai on a study of the 'Plucking Methods' from 28.10.78 to 30.10.78 and from 26.12.78 to 31.12.78.

Mr. B.S. Kotoky attended the Sixth Course on Administrative Management in R & D organised by CSIR at N.C.L., Poona from 3.6.78 to 21.6.78.

Dr. I.D. Singh visited National Botanical Garden, Lucknow from 20.12.78 to 22.12.78; Indian Agricultural Research Institute, New Delhi on 26.12.78 and Delhi University on 27.12.78.

Dr. P.N. Rustagi visited Delhi University; Indian Agricultural Research Institute from 26.12.78 to 30.12.78; Bose Institute at Calcutta; UPASI, Madras, get-together of former DAAD scholars and ICRISAT in Hyderabad from 15.2.79 to 2.3.79. He also attended the Seminar on 'Physiological Basis of Crop Productivity and Harvesting Solar Energy in Relation to Agricultural Development at Aligarh from 16.3.79 to 24.3.79.

Messrs S. Hussain & P C. Sharma, SSAs of Botany Department were on study leave and obtained their M.Sc. degree in Botany from Gauhati University.

Mr. K.K. Gohain, SSA of Soils & Meteorology Department is on study leave for M.Sc. in Physics at Dibrugarh University.

Mr. J.C. Jain, SSA of Biochemistry Department was at Indian Institute of Science Bangalore for two months for a training in enzymology.

Mr. G.G. Joshi, Documentation Assistant of Library & Publication Department is on study leave for M.Lib. Sc. at Gauhati University for one year.

## VISITORS

The following scientists and distinguished persons visited Tocklai during the year under review :

Mr. Roland Michaud, Paris, France.

Mr. Robert H. Dick, Chief Tea Examiner, U.S.A.

Mr. Stewart B. Duff, George Williamson & Co. Ltd., London.

Mr. John E. Gilbody, George Williamson & Co. Ltd., London.

Mr. K. Mishra, Deputy Chairman, Tea Board, Calcutta.

Dr. Jaswant Singh, Prof. & Head, Agric. Engg. Department, IIT, Kharagpur.

Mr. F.R. Wilson, Director, Assam Investments Ltd., London.

Mr. B.S.V. Rao, Director, Automobile Research Association, Pune.

Mr. J.A. Thompson, British High Commissioner to India.

Prof. M.R.M. Herbert of Building Research Station, U.K.

Mr. R.L. Perkins, American Consul General, Calcutta.

Mr. & Dr. F.G. Ashworth, Department of History, Highfield University, U.K.

Mr. M. Isa Darmawijaya, Plant Breeder, Research Institute for Tea & Cinchona, Indonesia.

Dr. K.C. Sahu, Prof. & Head, Industrial Management Centre, IIT, Kharagpur.

Mr. T. Balakrishnan, Jt. Secretary, Ministry of Commerce, New Delhi.

Mr. M. Varadarajan, Jt. Secretary, Ministry of Petroleum Chemicals & Fertilizers, New Delhi.

Prof. M.L. Dantwala, Former Chairman of Agricultural Prices Commission and now President, Indian Society of Agricultural Economists.

Prof. V.S. Vyas, Director, Indian Institute of Management, Ahmedabad.

Prof. T.D.J. Nagabhushanam, Principal, Agricultural College, Andhra Pradesh Agricultural University, A.P.

Dr. S.L. Shah, Prof. of Ag. Economics, G.B. Pant University.

Dr. V.M. Vakhade, Indian Society of Ag. Economics

Dr. Ram Iqbal, Prof. & Ag. Economist, C.S.A. Agricultural University, Kanpur.

Dr. D.S. Sidhu, Prof. & Head, Department of Economic & Social Sciences, Punjab Agricultural University, Ludhiana.

Mr. A. Bathrak, Overseas Development Institute, London.

Mr. N .K. Thingalaya, Chief Economic Adviser, Syndicate Bank, Manipal.

Mr. K. Singh, Department of Ag. Economics, Pantnagar.

Mr. V.K. Duggal, Director, Tea Promotion, Sydney.

Mr. P.C. Kochhar, A.F.C.D.E., Bangalore.

Mr. E. Desmond Heath, (formerly Advisory Officer Tocklai now a consultant) Cheslive, U.K.

Prof. Dr. K. Hartke, West Germany.

Mrs. H. Heine, West Germany.

Dr. Y.S. Sadanandam, Scientist, R.R.L., Hyderabad.

Dr. Robert F. Goheen, U.S. Ambassador to India.

Mr. Mohan Dharia, Minister of Commerce, Govt. of India.

Mr. Dulal Chandra Baruah, State Minister of PWD, Supply & Jail, Assam.

Mr. Golap Chandra Barbora, Chief Minister, Assam.

Mr. P.K. Kaul, Additional Secretary, Ministry of Commerce, Govt. of India, New Delhi.

Mr. P.C. Mahendru, Assistant Director, National Physical Laboratory, New Delhi.

Mr. K.S. Madappa, Executor, F.E. & Figgis (P) Ltd., Cochin.

Mr. H.R. Joesoef Argadipadia, Director, Production State Owned Estate XII, Bandung, Indonesia.

Mr. Bambang Wibow, Director, NV Tambi Wonosobo, Indonesia.

Dr. Hediyono, Senior Official, Department of Trade & Co-operatives, Indonesia.

Dr. Haryono Semangun, Chairman, Indonesian Tea Association, Bandung, Indonesia.

Mr. G. E. Howard, Tropical Products Institute London.

Mr. K.R.M. Anthony, N.R. Economics & Management Adviser, Overseas Development Administration, London.

Mr. G.D. Gwyer, N.R. Economics & Management Adviser, Overseas Development Administration, London.

Mr. M. Lamond, Director, McLeod & Co. Ltd., London, former Chairman, London Scientific Committee of TRA.

Mr. Huska, Minister, Agriculture & Co-operative, Nagaland.

Mr. K.S. Puri, Secretary (Agriculture), Nagaland.

Mr. R. Kevichusa, Agricultural Engineer, Nagaland.

Mrs. P.P. Trivedi, Agricultural Production Commissioner, Govt. of Assam, Gauhati.

Mr. A.L. Sethi, General Manager, Empire Singlo Tea Co. Ltd.

Mr. H.W. Dikon, Director, Singlo Holdings, London.

Mr. Jack Genia of Laws Surveys & Environment, Papua New Guinea.

Mr. Floyd Palialu, National Plantation Management Agency, Papua New Guinea.

Dr. R.C. Bishnu, Scientist, Central Mechanical Engineering Research Institute, Durgapur.

Mr. M.K. Banerjee, Scientist, General Mechanical Engineering Research Institute, Durgapur.

Mr. Prakash Tandon, Chairman of the Govt. of India Committee to study Tea Marketing, and Director General, National Council of Applied Economic Research.

Mr. B.K. Goswami, Chairman, Tea Board.

Mr. J.R. Glawville, Bandanga, Malawi.

Brig. K.B. Narang, ESG, HQ DRDO, New Delhi

Lt. Gen. WHG Pinto, Comdt., National Defence College, New Delhi.

# Library and Publication

## General

The Central Library of Tocklai Experimental Station supplied regularly books and other publications to each of the eleven departmental libraries at Tocklai and five out-station branch libraries. During the year 114 new books requisitioned by the Scientists of Tocklai and out-stations were added in the Library. Tocklai subscribed for 144 journals, Indian and foreign and discontinued 4 journals. Besides these 105 journals were received in exchange of Tocklai publications and on free basis.

The post of Cataloguer has been filled up in the month of September, 1978.

## Library Statistics

The following were received in the Library during the year under review :

| | | |
|---|---|---|
| Periodicals & Journals on subscription ... | 910 | Issues |
| Periodicals & Journals on free & exchange ... | 403 | Issues |
| Pamphlets & Bulletins ... | 580 | Nos. |
| Photocopies ... | 7 | Nos. |
| Reprints ... | 18 | Nos. |
| Map ... | 1 | No. |
| Publications consulted in library ... | 4100 | Nos. |
| Publications issued to departments ... | 2339 | Nos. |
| Publications received back from depts. ... | 1633 | Nos. |
| Journal volumes bound during the year ... ... ... | 160 | Nos. |

## Library Service

Besides serving the Scientists of the Station, Library services are being regularly offered to persons not connected with Tocklai. Post Graduate Students from Assam Agricultural University, Jorhat; Engineering College, Jorhat; Honours students of local Science Colleges; Students from H.R.H. Prince of Wales Engineering Institute, Jorhat have used the Library throughout the year. Scientists from Regional Research Laboratory, Jorhat; Persons from Department of Agriculture, Govt. of Assam; several Lecturers from J.B. College, Jorhat; Bahona College, Jorhat also used the Library. One Year Trainess, V.P. Trainess from T.R.A. member estates have also utilized the Library facilities throughout the year.

A few Scientists from out-side e.g. National Physical Laboratory, Delhi; I.I.T. Kharagpur; who were in search of literature & bibliographic help, also used the library.

## Documentation & Information

This section of this department has shown remarkable activity throughout the year under review. A monthly Accession List, showing the titles of publications received by the Library is published regularly. In all six Bibliographical lists containing selected articles covering all the subject fields of interest of the Station from the Journals and Periodicals received throughout the year were circulated to all departments of Tocklai and out-stations. Besides these, half-yearly 'Bulletin of Documentation on Tea' carrying abstracts of important scientific articles on tea published in the Journals & Periodicals received by the Library was also circulated.

Books procured by the Library are catalogued in cards readily accessible to clientele of the Library under the (Subject, Title and Author) three main possible approaches, and now are in use.

A bibliographical index of Journal and Periodical holding of the Library since its inception is being prepared and will be published and circulated in due course.

News Paper cuttings relating to Tea and other important topics are being continued and information files increased during the year. Various reference questions were answered regarding Tea Trade and Industry satisfying the quaries made by Scientists of the Station and from out-side.

The bibliography of Tea is also made ready for use in the card cabinet and regular charging of it is being continued throughout the year.

Bibliographies on other subjects are taken in hand.

An index of articles on tea published in Two and A Bud is prepared.

## PUBLICATION

The following publications were issued from Tocklai during the year.

1. (a) *Two & A Bud*, Vol. 25, Nos. 1 & 2.
   (b) *Tocklai News*, Nos. 7 & 8.

2. **Tea Encyclopaedia Serials**
   (a) No. 48/2 Control of Red Slug Caterpillar (revised).
   (b) No. 53/4 Medium Pruning. (revised)
   (c) No. 106/1 *Helopeltis theivora* Waterh. (Tea Helopeltis) (revised)
   (d) No. 110/4 Compatibility of Insecticides, Acaricides Fungicides and Nutrients commonly used in Tea. (revised)
   (e) No. 161/1 Scarlet Mite. (revised)
   (f) No. 167/1 Biology and Control of Cockchafer. (revised)

(g) No. 195 Lymantriid Caterpillars. (revised)
(h) No. 196 Deep, Medium, Light and Level Skiffs. (revised)

3. **Advisory Leaflet**
(a) No. 11 Shot-Hole Borer in Tea : A warning Note by—B. Banerjee.

4. **Advisory Bulletin**
(a) No. 9 Toxicity symptoms of commonly used Herbicides on Tea by –V.S. Rao.

5. **Special Bulletin**
(a) No. 2 Soil Conditions and Rainfall Distribution of Dibrugarh Tea District. (Moran, Dibrugarh, Panitola, Nahorkatia & Tingrai Part ) by—P. Ghosh, R.C. Chakravarty, K. K. Gohain and S.K. Dey.

6. **Other Reports**

(a) Annual Scientific Report for 1977-78.

(b) Engineering Research & Development Department Quarterly Reports for quarter ending 30th June, 30th Sept, 31st Dec. 1978 and 31st March, 1979. (cyclostyled) .

(c) Contribution of Tocklai Experimental Station to the Tea Industry of North-East India. (cyclostyled) .

## Highlights

*There is a widespread consciousness and interest to participate more and more in different Area Scientific Committee meetings and Seminars.*

*Due to the present need for the recent field management practices, active participation in these courses from the member gardens has increased recently.*

*With the enrolment of more number of member estates, the Advisory Officers had to help in drawing out in details, the annual programme and take up the follow-up actions, specially in the underdeveloped estates.*

*More emphasis was given by the planters for pump drainage project in problem areas, which indicates a progressive attitude towards sophisticated drainage system to come into bearing.*

*Bud grafting has been taken into consideration as the most effective tool for quick multiplication of clones.*

*The Clonal Proving Station in Darjeeling helped the release of different clones suitable for that region.*

*In many member estates, eagerness has developed to establish their own 'seed bari' for production of recent introductions of bi-clonal seeds from Tocklai.*

*From estate experiments it is becoming clear that balanced fertilizer in relation to specific soil and climate would be more appropriate.*

## General

One of the main functions of this Department has been to advise the member estates regularly whenever there has been any problem in the field management practices. With the enrolment of new members in the recent years, it has become necessary to go into details of pruning, manuring and other items of management and in many cases the Advisory Officers has to help in drawing out the annual programme and take follow up measures. The demand for this type of services has been increasing and appointments are being made in a phased manner to raise the strength of Advisory Officers.

## Advisory visits

Personalised service through advisory visits is the distinctive feature of Tocklai to its members. Inspite of strain on its resources, every attempt is being made to maintain this personalised service. The comparative advisory visits are shown in Table 2.01.

## Area Scientific Committee Meetings

As the primary forum of group discussions, scientific committee meetings have become increasingly popular which is evident from the data in Table 2.02. The number of Tocklai Officers is also quite large at these meetings.

**Table 2.01.** *Details of Advisory visits paid in the member estates during 1977-78 and 1978-79*

| District | No. of visits paid during | | No. of member estates visited during | | Total number of member estates during | |
|---|---|---|---|---|---|---|
| | 1977-78 | 1978-79 | 1977-78 | 1978-79 | 1977-78 | 1978-79 |
| South Bank (including Upper Assam) | 595 | 452 | 305 | 302 | 353 | 362 |
| North Bank | 183 | 230 | 77 | 91 | 94 | 93 |
| Cachar (including Tripura) | 162 | 275 | 76 | 86 | 88 | 87 |
| Dooars | 395 | 271 | 109 | 107 | 125 | 124 |
| Terai | 165 | 135 | 36 | 38 | 36 | 41 |
| Darjeeling (including Sikkim) | 131 | 178 | 68 | 75 | 75 | 80 |
| Total: | 1631 | 1541 | 671 | 699 | 771 | 787 |

**Table 2.02.** *Number of ASC Meetings showing total number of planters and Tocklai Officers attended*

| Area | Date | No. of persons attended | |
|---|---|---|---|
| | | Planters | Tocklai Officers |
| South Bank (Assam) East (1) | 29.7.78 | 65 | 5 |
| | 7.11.78 | 108 | |
| South Bank (Assam) Central (2) | 15.5.78 | 39 | 8 |
| | 9.8.78 | 43 | 5 |
| | 30.11.78 | 33 | 5 |
| Joint Meeting of All Areas | 28-30.9.78 | 152 | 23 |
| South Bank (Assam) West (3) | 3.4.78 | 42 | 6 |
| | 4.8.78 | 39 | 9 |
| | 4.12.78 | 155 | 7 |
| North Bank (Assam) East | 26.3.79 | 19 | 3 |
| North Bank (Assam) West | 30.3.79 | 23 | 4 |
| Combined Meeting of North Bank East & West | 25.11.78 | 29 | 2 |
| Cachar | 30.6.78 | 103 | 6 |
| | 19.10.78 | 111 | 4 |
| Dooars | 15.5.78 | 105 | 10 |
| | 16.8.78 | 102 | 7 |
| | 23.10.78 | 66 | 6 |
| Terai | 17.5.78 | 29 | 13 |
| | 17.8.78 | 31 | 6 |
| | 6.12.78 | 44 | 4 |
| Darjeeling | 19.5.78 | 55 | 5 |
| | 5.7.78 | 16 | 1 |

With the area scientific committee meetings, open sessions were also held for the planters of the area to discuss the local problems and these were well attended.

## Joint Area Scientific Committee Meeting held at Moran, Dibrugarh and Panitola from 28th to 30th September

Area 2 of Upper Assam (covering Moran, Dibrugarh and Panitola) hosted the Joint Area Scientific Committee Meeting during the period 28th to 30th September, 1978.

Organised attempts to solve various problems in this high yielding high quality tea producing area, the progress made so far in respect of peculiar drainage problem, cultural practices, growing high yielding teas, raising large good clonal nurseries, establishing micro seed bari, reclamation of marginal land (in respect of drainage) for tea planting, bud grafting as a technique of clonal multiplication, the success of enclosed withering through, performance of Tocklai Continuous Fermenting machine, pumped drainage project, green tea manufacture-Japanese way, erosion control measures etc., were the highlights of this three-day convention where, besides planters of this region, about 150 planters and scientists from North East and South India assembled for discussion.

## Seminars

The details of seminars held during 1978-79 are given in Table 2.03.

**Table 2.03.** *Titles of seminar in different areas*

| Area | Date | Subject |
|---|---|---|
| South Bank East | 29 July 1978 | Plant Protection |
| | 7 Nov. 1978 | Engineering & Manufacture |
| South Bank Central | 15 May 1978 | Plant Protection |
| | 9 Aug. 1978 | Engineering & Manufacture |
| | 30 Nov. 1978 | Agriculture, Botany & Soil Science |
| South Bank West | 3 April 1978 | Engineering & Manufacture |
| | 4 Aug. 1978 | Agriculture, Botany & Soil Science |
| | 14 Dec. 1978 | Plant Protection |
| North Bank East | 26 Mar. 1979 | Plant Protection |
| North Bank West | 30 Mar. 1979 | Plant Protection |
| North Bank E & W. | 21-24 Aug. 1978 | Engineering & Manufacture |
| Cachar | 30 June 1978 | Agriculture, Botany & Soil Science |
| | 19 Oct. 1978 | Engineering & Manufacture |
| Dooars | 15 May 1978 | Agriculture, Botany & Soil Science |
| | 16 Aug. 1978 | Plant Protection |
| | 23 Oct. 1978 | Engineering & Manufacture |
| Terai | 17 May 1978 | Agriculture, Botany & Soil Science |
| | 17 Aug. 1978 | Plant Protection |
| | 6 Dec. 1978 | Drainage |
| Darjeeling | 9 May 1978 | Production |
| | 15-16 Sep. 1978 | "Operation 15 Qtls." |
| | 23 Mar. 1979 | Engineering & Manufacture |
| | 8-9 Dec. 1978 | Two one-day seminar for planters on : 1) Drainage and conservation practice 2) Young tea management and bud grafting |

## Lecture Courses

The following courses were organized by Advisory Department at Tocklai, apart from those held by Agritural Economics and Agronomy Departments, with the help of Specialists from other Departments.

Field Management : 2 Courses (each of 4 days' duration). These courses were run earlier but these were discontinued over a decade. However, of late, as new development in the field management have been achieved and many new incumbents have joined the tea industry, it was felt necessary to re-start these courses from 1976, and during the year 44 planters attended.

Surveying & Drainage : 3 Courses (each of 5 days' duration).

These courses have been run since 1968 and this year 63 planters attended.

## Distribution of cuttings

The details of distribution of cuttings, generative clones and seeds from Tocklai (Borbhetta) and various outstations to member estates are given in Table 2.04.

**Table 2.04.** *Distribution of cuttings, scions, generative clones and seeds from Tocklai and outstations*

| Outstations | V. P. cuttings | Scions | Generative cuttings | Generative scions | Seeds in in kg |
|---|---|---|---|---|---|
| South Bank | 17,46,669 | 1,410 | 24,414 | 830 | 500 |
| North Bank | 1,40,750 | 1,140 | — | — | — |
| Cachar | 2,27,785 | — | — | — | — |
| Dooars & Terai | 3,01,055 | 920 | 17,675 | 540 | — |
| Total : | 24,16,259 | 3,470 | 42,039 | 1,370 | 500 |

## Experiments

The following experiments were in progress in Nagrakata Sub-Station :

1) D. 48 : Nitrogen response to different clones. Six Tocklai release clones *viz.* TV 1, TV 9, TV 11, TV 12, TV 16 and TV 18 with 4 different levels of nitrogen *viz.* 100, 200, 300 and 300 kg N/ha plus 150 kg $P_2O_5$ plus 150 kg $K_2O$/ha were included in this trial.

Clone TV 12 produced significantly higher yield over other clones followed by clone TV 16, but there was no significant difference between TV 12 and TV 16 Manurial treatments failed to show any significant superiority in 1977. However, TV 12 under 300 kg N, 150 kg $P_2O_5$ and 150 kg $K_2O$ per hectare produced the highest yield.

2) D. 61 : Agricultural trial with different clones. Eleven Tocklai release clones, Stock 203

and one Mal clone *viz.* TV 1, TV 4, TV 7, TV 8, TV 9, TV 10, TV 11, TV 12, TV 14, TV 16 and TV 17 and NG/5/79 (Mal clone), Stock 203 were included in this trial.

In 1977, TV 17 produced significantly the highest crop over all the other clones except TV 14, TV 12 and TV 1 amongst which there were no significant difference in yield.

3) D. 62 : New Agricultural trial with different clones. Six Tocklai release clones *viz.* TV 1, TV 9, TV 17, TV 18, TV 19 and TV 20, Stock 203 and other 8 non-release clones were also included in this trial (earmarked for future release).

In 1978, clone TV 19 produced significantly the highest crop over all the other clones. TV 19 was followed by clones TV 20, TV 17, TV 18 and B/5/63 (non-released clone), which had no significant difference amongst them.

4) D. 77 : Spacing trial (Fan design)
This trial was laid out in the year 1977/78 to study the effect of spacing with clone TV 1 with 22 different spacings varying from 30 cm × 30 cm to 120 cm × 120 cm.

5) D. 212 : Bielonal Stock trial
Seven stocks *Viz* 460, 461, 462, 463, 464, 449 (already released), 378 (released for Darjeeling estates) and clone TV 1 were included in this trial

From yield and quality trend, one Stock, TS 462 appears to be promising and likely to be released in near future.

**Clonal Froving Station (Darjeeling)**

One more clone *viz.* TS 383 was selected for release to the industry. During the year 700 samples were manufactured for evaluation of quality. Trial 'E' was handed over to the management of Ging T.E. after taking all observations required. Eight new clones were planted out during the year. These are :

1. T. 24
2. HV. 39
3. P. 1258
4. T. 1
5. BT/6/8/117
6. BT/22A/81
7. Sundaram
8. TKV. 1

**Research & Development Scheme**

The research and development scheme for industry's participation initiated a few years ago, has been continuing. Gradually a number of companies/estates are coming forward and are showing eagerness to try out certain possibilities under their own conditions and decide the best treatments for themselves. Under this scheme experiments have been started in fifteen estates. The vital role of selecting out the treatments, site selection, imposition of treatments, coordination and analysis of data, is still being done from Tocklai. The results are given under estate experiments where the data of experiments from cooperating estates have been analysed in combination with those of similar experiments from other estate trials.

COMMENTS ON SOME AGRICULTURAL PRACTICES

**Land Planning and Drainage**

While proper land planning and drainage continued to be adopted by larger number of estates, pump drainage system, particularly wherever outfall is restricted, to be gaining ground. Although the initial investment on this system is high, thanks to the Seminars, Area Scientific Committee and Joint Area Scientific Committee meetings, there is a greater realisation that the amount initially spent on this project is definitely worthwhile and the return is manifold.

With the opening of the Tripura Advisory Centre the estates in Tripura had for the first time the benefit of understanding the magnitude of the drainage problem and realisation of the advantages accruing from land planning and correct drainage system.

While outlet has been a greater problem in most of the other parts, the need for the conservations of soil and guided disposal of surplus surface water has been well understood by the Darjeeling estates. It is heartening to report that apart from other standard methods of soil and water conservation practices, planting of Guatemala grass and Mimosa was taken up by many estates of Darjeeling.

**Pruning Cycle**

The Advisory Officers during their routine visits, have been explaining to the management that one standard pruning cycle for the entire estate may not be suitable. There is a trend to reduce the cycle from 4/5 years to a comparatively shorter one. From the discussions it appears that this is a result of the quality conscious market as well as recurrent failure of the lighter forms of skiff to yield more early crop due to droughty conditions.

The importance of lowering the height of the permanent frame at the rate of around 4 to 5 percent annually had also been emphasised.

Reports of die-back after pruning/skiffing have been received from many areas. It has been felt that in more recent years plucking has been continued even until December and in many cases pruning/skiffing started immediately after cessation of plucking. It is possible that the starch reserves in the roots were not adequate

and therefore the estates are now being advised to rest the bushes before pruning.

**Rejuvenation**

Rejuvenation pruning has been taken up by estates in all areas. A general experience has been that rejuvenation pruning below 45 cm from the ground is better avoided to reduce the chances of higher mortality. The direct benefits from rejuvenation pruning started showing up only after 3/4 years depending on the recovery of the pruned bushes and the successful implementation of associated measures like drainage, shade etc. In some cases increase in yield around 20% was observed in the 4th year after pruning and infilling. Subsequently from the 6th year the yield increase has been around 35 per cent.

However, in some cases rejuvenation pruning has failed to show good results. The main causes of failure have been due to pruning at a time when the starch reserve has been inadequate, followed by failure of planting out shade, failure of early rains etc. Use of undersized plants for infilling and lack of proper maintenance of the infills also contributed towards its failure in some cases.

In Darjeeling rejuvenation pruning has at last been taken up in 16 estates and is an accepted field management practice for the benefit of old tea. The Tea Board gives a subsidy for rejuvenation only in hilly areas of Darjeeling in N.E. India.

Infilling in mature, rejuvenated or medium pruned tea has been taken up with care by a limited number of companies/estates. There is however a tendency as well to infill some of the younger teas whenever extra plants are available.

**Young Tea**

In Assam, particularly in the South Bank, where drought is not very severe, pegging of young tea has been increasingly practised. It has been observed that bending of the plants could be done soon after they were established on the gorund. Subsequent pegging, only when the laterals attained the height of not less than 40 to 50 cm, had given better result. The other main observation has been that the primaries arising from the base of the pegged branches and/or below the initial bend, were more vigorous than the ones arising from centre or the periphery of the pegged branches. To obviate this differential growth, it has been suggested that the central branches could be suppressed at around 30 to 35 cm from the ground, while the others are allowed to reach the predetermined height. The table is then formed at a suitable height and the frame is finally formed with subsequent frame forming prune etc. In areas where planting has been delayed until about the cold weather and/or where the starch reserve has not been fully sufficient to take the prune, long pruning had given better result.

In other areas where due to droughty conditions or where tea was planted in stoney, lighter texture soil, pegging has been discouraged primarily due to heavy scorching observed in those areas and high mortality after pegging. In such places decentering and pruning followed by frame forming prune at a suitable time was suggested. In more progressive concerns, where the field management practices have been maintained in a higher standard, a population between 14,000 to 16,000 per hectare has been favoured, while in other estates higher population has been the normal practice.

**Planting**

Extension planting, wherever land is available has been given top priority. The rate of replanting in most cases still remains below 2 per cent.

Undersized planting pits are still common. In addition, the tendency to plant the clonal plants somewhat deeper has been observed. In areas with heavy or stoney sub-soil trench-planting has been advocated. In majority of the estates the recommended dose of superphosphate and cattle manure or compost has been applied.

**Mulching**

Mulching of young tea which was very widely practised during the last few years appears to be on the decline. The reasons could be (1) the rising cost of mulching; and (2) non-availability of material, particularly due to larger area being planted within a year. Inspite of these difficulties it has been stressed that mulching is extremely essential.

**Vegetative propagation**

The Advisory Officers consistently hammered on the need of keeping the side walls of the overhead nurseries until such time that the drought was definitely over. It was also pointed out that rooted cuttings are better not planted in drought. Half leaf cuttings were successfully propagated on a large scale in some estates.

Vegetative propagation appears to have taken a good start in Darjeeling district as well. It is estimated that about 6 million cuttings were already planted in the nursery while preparations were on for more to go in the next year.

Special attention was paid to make bud grafting more popular for future vegetative propagation in Darjeeling and a seminar was also conducted on the subject.

**Seed**

Following the Joint Area Scientific Committee meeting in Area 2 where the need for establishing biclonal seed baris in each estate was emphasised, there has been more awareness to follow the scheme wherever this is possible. The estates are being cautioned about supply of spurious biclonal seeds by some suppliers and are being requested to buy seeds from registered growers only.

Heavy demand for Nandadevi seed in Darjeeling continued. Most of the seed and clonal plants are being used for infilling in Darjeeling.

**Phosphate and Potash manuring**

Application of phosphate and potash mostly continued as in the previous years except that in some areas like Cachar phosphate could not be applied due to non-availability of phosphatic fertilizer. Use of Rock-phosphate has been gaining popularity.

In the Dooars estates have started applying potash at the rate of 60 to 100 kg $K_2O$ per hectare on the basis of soil analysis and in some cases autumn application of potash is also being tried.

**Spraying of Micro nutrients and other elements**

Zinc sulphate has been tried by a number of estates in the North and South Banks of Assam and in the Dooars. In Assam as well as in the Dooars some estates, however, preferred to wait until the results of micro-nutrient trials started by Tocklai are available. Reduction in the use of commercial micro nutrient mixtures by estates has been noticed.

**Manuring of Young Tea**

Liberal manuring of young tea continued with 2:1:2 or 2:1:3 mixtures depending on the potash status of the soil. This young tea manure mixture was applied at the rate of 90 to 120 kg nitrogen per hectare during the first and the second year and were raised upto 130 to 140 kg during 3rd and the 4th year in the South Bank, particularly where the yield progesion receiving liberal manuring was satisfactory. During the first three years the fertilisers were applied in 3 to 4 splits depending on the availability of labour and the start of manuring in the year. Cases of over-manuring were also observed where the bushes were dying and at other places mortality was observed due to manure injury at the collar region.

In some areas like Tripura, young tea was manured with NPK mixture at equal proportions. However, from 1978 season introduction of YTD manure mixture in the estates was initiated.

**Weed Control**

Use of Simazine as pre-emergent herbicide in newly planted sections was popular as well as effective. The Gramoxone/2,4-D cocktail was used more extensively and many estates have tended to go for even Karmex with good results. Thatch has, however, been difficult to control with Gramoxone alone, particularly in young tea where Dalapon could not be used. And the estates have been hopefully wating for Glyphosate (Round up) to be available durig the coming year. Although manual cultivation particularly in mature tea was still being practised by some estates, in most of the estates where herbicide programme was taken up with interest, cheeling was discouraged unless the soil was too compact.

**Shade**

A good number of estates are almost entirely shaded by *Albizzia odoratissima*, the choice of suitable shade trees being limited. Introduction of new shade trees is eagerly awaited.

The estates were being advised to use a mixture of at least three four species, the others being *A. lebbek*, *Derris robusta*, *Acacia lenticularis* and even *Albizzia chinensis*.

In Darjeeling *Sesbania sinerescences* proved successful both at low and medium elevations and its seeds could be planted *in situ* with advantage. Wind damage was however high due to soft branches.

**Pest Control**

Moderate to severe incidence of thrips, red spider and scarlet mite in the early season was experienced in North Bank, Tripura, Dooars, Terai and Darjeeling. Incidence of pests were low in South Bank. By and large planters used pesticides well in time, which prevented outbreak of some of the major pests.

Loopers were prevalent in the North Bank and Terai.

The need of more effective sprayers has been increasingly felt by planters in all areas.

**Disease Control**

Red Rust continued to be a dominating disease. Black Rot incidence has been lower, due to avoiding unprune/skiff in the affected areas and regular spraying.

Red Root Rot was again found in South Bank.

A root splitting disease was recorded in two more estates in Darjeeling.

Blister blight attack was at its normal level of incidence in Darjeeling and less than previous year in Terai.

Soil fumigation against primary root diseases has been resorted to in limited number of gardens.

**Officers and Staff postings/transfers/retirements**

Dr. P.C. Sharma, retired as Head, Advisory Department and Mr. S. Basu took over as Head with effect from 1st April, 1978. On his promotion to the post of Deputy-Director, Nagrakata, he handed over the charge of this Department to Dr. T.K. Ghosh on 1st January 1979. Mr. H. Mitra, Advisory Officer, West Bengal retired on 26th August. The following transfers were effected ;

Mr. B.C. Barbora - From Dooars to North Bank in January 1979.

Mr. B. Borthakur — From South Bank to North Bank in July 1978.

Mr. B.C. Phukan — From Terai to Dooars in December, 1978.

The following postings were made :

Dr. D.N. Chakraborty — Advisory Officer, South Bank in July 1978.

Mr. R. Das Gupta — Asst. Advisory Officer, Dooars in January 1979.

Mr. A.K. Bhargava was appointed as Asst. Advisory Officer in July 1978 and posted at Terai in February 1979.

Dr. S. Basu, who remained associated with Agronomy Department, is likely to return to this Department with effect from April 1979.

The following members of the staff were appointed during the year :

Sri Dulal Ch. Dutta as Field Assistant in Upper Assam.

Sri Kalyan Kr. Bhattacharyya as Field Asst. in Nagrakata.

Sri Ajit Krishna Das as Accounts Asst. in Nagrakata.

Sri Nirmal Kansa Banik as Accounts Asst. in Tripura.

Sri Bidhan Ch. Saikia as Accounts Asst. in North Bank.

Sri S.N. Misra as Clerk Typist in Nagrakata.

Miss Rani Goldsmith as Museum Attendant at Tocklai.

Sri B.K. Hazarika, Field Assistant, posted at Dikom, resigned with effect from 1st September, 1978.

**Estate Experiments**

As in the previous years, the estate experiment were continued by this Department in various estates of North-East India. It has become increasingly clear that regional recommendations will flow out from these experiments, conducted under different agro-climatic regions.

The treatments of the new series of experiments on micronutrients, initiated last year, were imposed and are intended to be continued further.

Some of the experiments e.g. comparison of different systems of plucking, foliar application of zinc etc were completed and the combined analyses of the results are in progress. The trends show that apart from some common findings there may be some differential response to the treatments in different regions.

# Summary of Results

Summaries of a few interesting experiments conducted by this Department are given below :

## 1.(a) Plucking Experiments

Eight experiments, two in South Bank, one in North Bank, two in Cachar and three in the Dooars, were initiated in 1974 to compare the yield from $T_1$ (Black plucking) and $T_2$ (Standard plucking) under different types of pruning. In 1978, pruning treatments included $M_1$ (unprune), $M_2$ (prune), $M_3$ (deep skiff) and $M_4$ (medium skiff).

### (i) Assam South Bank Experiments (As.126 & As. 133)

Two experiments, one each in Nahortoli and Lohpohia Tea Estates, were conducted in the South Bank. The results are presented in Table 2.05.

**Table 2.05.** *Yield KMTH* of 1978 under Black and Standard Plucking systems in South Bank Experiments*

| Experiment No. | Plucking treatment | Unprune | Light prune | Deep skiff | Medium skiff | Mean |
|---|---|---|---|---|---|---|
| As. 126 (NAHOR-TOLI TE) | Black Plucking | 1532 | 860 | 1288 | 1352 | 1258 |
| | Standard Plucking | 1752 | 1033 | 1248 | 1535 | 1392 |
| | Mean | 1642 | 947 | 1268 | 1443 | |
| | Critical difference for pruning/skiffing treatment means (P=0.05) | | | | | 249 |
| | Critical difference for plucking treatment means (P=0.05) | | | | | 71 |
| | $CV_1$ % (Pruning/skiffing) | | | | | 8.36 |
| | $CV_2$ % (Plucking) | | | | | 3.88 |
| As. 133 (LOHPO-HIA TE) | Black plucking | 1283 | 876 | 916 | 1273 | 1087 |
| | Standard plucking | 1302 | 1000 | 1212 | 1374 | 1222 |
| | Mean | 1292 | 938 | 1064 | 1324 | |
| | Pruning/skiffing treatments effect | | | | | Not significant |
| | Plucking treatment effect | | | | | Not significant |
| | $CV_1$ % (Pruning/skiffing) | | | | | 19.37 |
| | $CV_2$ % (Plucking) | | | | | 11.96 |

*KMTH = Kilogram of made tea per ha

Analysis of results of 1978 showed that in Nahortoli TE (As.126) standard plucking recorded significantly more crop than black plucking. More crop was also produced by unprune over prune and deep skiff treatments. In Lohpohia TE (As.133), though standard plucking yielded more crop than black plucking under various types of pruning skiffing, the difference was not statistically significant.

### (ii) North Bank (Assam) Experiment (An.139)

One experiment was conducted in Dhullie TE (An.139) in the North Bank. The results are presented in Table 2.06.

**Table 2.06.** *Yield KMTH of 1978 under Black and Standard Plucking systems in North Bank Experiments*

| Experiment No. | Plucking treatment | Unprune | Light prune | Deep skiff | Medium skiff | Mean |
|---|---|---|---|---|---|---|
| An. 139 (DHULLIE T.E.) | Black plucking | 1522 | 1386 | 1312 | 1369 | 1397 |
| | Standard plucking | 1707 | 1504 | 1642 | 1635 | 1622 |
| | Mean | 1614 | 1445 | 1477 | 1502 | |
| | Pruning/skiffing treatment effect | | | | | Not significant |
| | Critical difference for plucking treatment means (P=0.05) | | | | | 116 |
| | $CV_1$ % (Pruning/skiffing) | | | | | 12.14 |
| | $CV_2$ % (Plucking) | | | | | 4.55 |

Analysis of results of 1978 showed that standard plucking yielded more crop than black plucking under various pruning/skiffing treatments.

### (iii) Cachar Experiments (C.45 & C.46)

Two experiments, one each in Hattikhira (C.45) and Silcoorie (C.46) Tea Estates, were continued, where results indicated that there was not much difference in yield between black plucking and standard plucking during 1978.

### (iv) Dooars & Terai (West Bengal) Experiments

Three experiments, one each in Birpara (D.58) Dalsingpara (D.59) and Hansqua (TR.60) Tea Estates were continued in 1978. The results are presented in Table 2.07.

In Birpara TE (D.58), though standard plucking yielded more crop than black plucking, the difference was not statistically significant. More crop was produced by unprune tea than by deep skiff, medium skiff and light prune treatments under both the systems of plucking.

In Dalsingpara TE (D.59), standard plucking recorded more crop than black plucking and increase in yield from unprune treatment was found significant over prune and deep skiff treatments.

In Hansqua TE (TR.60), standard plucking under various pruning/skiffing treatments produced more crop than black plucking and unprune treatment yielded significantly higher crop than other pruning/skiffing treatments.

**Table 2.07.** *Yield KMTH of 1978 under Black and Standard Plucking systems in the Dooars & Terai Expts*

| Experiment No. | Plucking treatment | Unprune | Light prune | Deep skiff | Medium skiff | Mean |
|---|---|---|---|---|---|---|
| | Black plucking | 3405 | 1978 | 2598 | 2633 | 2654 |
| | Standard plucking | 3557 | 1831 | 2951 | 2915 | 2814 |
| D. 58 | Mean | 3481 | 1904 | 2775 | 2774 | |
| (BIR-PARA T.E) | Critical difference for pruning/skiffing treatment means (P=0.05) | | | | | 437 |
| | Plucking treatment effects | | | | | Not significant |
| | $CV_1$ % (Pruning/skiffing) | | | | | 7.10 |
| | $CV_2$ % (Plucking) | | | | | 7.76 |
| | Black plucking | 2121 | 1116 | 1476 | 1728 | 1610 |
| | Standard plucking | 2259 | 1156 | 1640 | 1899 | 1738 |
| D. 59 | Mean | 2190 | 1136 | 1558 | 1813 | |
| (DALSINGPARA TE) | Critical difference for pruning/skiffing treatment means (P=0.05) | | | | | 568 |
| | Critical difference for plucking treatment means (P=0.05) | | | | | 100 |
| | $CV_1$ % (Pruning/skiffing) | | | | | 15.08 |
| | $CV_2$ % (Plucking) | | | | | 4.30 |
| | Black plucking | 2660 | 1674 | 2112 | 1946 | 2098 |
| | Standard plucking | 2988 | 2029 | 2393 | 2326 | 2434 |
| TR. 60 | Mean | 2824 | 1851 | 2252 | 2136 | |
| (HANSQUA TE) | Critical difference for pruning/skiffing treatment means (P=0.05) | | | | | 242 |
| | Critical difference for plucking treatment means (P=0.05) | | | | | 10 |
| | $CV_1$ % (Pruning/skiffing) | | | | | 4.75 |
| | $CV_2$ % (Plucking) | | | | | 0.32 |

## 2. Manual & Chemical Weed Control : Chuapara TE (D.42)

This experiment was started in February 1970 to study the effects of three main types of manual cultivation in mature tea in the presence and absence of a chemical herbicide and with and without removing the weeds and pruning litters from the soil and then to find out the most suitable type of cultivation under the conditions of the experiment. The treatments are :

A = Cultivation at 3 levels : $A_1$ (Sickle), $A_2$ (Cheel) and $A_3$ (Light Hoe).

B = Herbicide at 2 levels : $B_1$ (Gramoxone) and $B_2$ (No herbicide)

C = Weed & Pruning litters at 2 levels (organic matter): $C_1$ (Litter left) & $C_2$ (Litter removed)

The results of 1978 are presented in table 2.08.

**Table 2.03.** *Yield KMTH of 1978 under different methods of Weed Control*

**Cultivation × Herbicide**

| Cultivation (A) / Herbicide (B) | Sickling | Cheeling | Light hoeing | Mean |
|---|---|---|---|---|
| Herbicide | 2596 | 2497 | 2572 | 2555 |
| No Herbicide | 2420 | 2381 | 2534 | 2445 |
| Mean | 2508 | 2439 | 2553 | |
| Critical difference between two A means (P=0.05) = 90 | | | | |
| Critical difference between two B means (P=0.05) = 73 | | | | |
| Interaction (A × B) | Not significant | | | |
| CV % | = 5.02 | | | |

**Herbicide × Organic Matter**

| Organic matter (C) / Herbicide (B) | Weeds & Pruning litters left | Weeds & Pruning litters removed | Mean |
|---|---|---|---|
| With Herbicide | 2619 | 2490 | 2555 |
| Without Herbicide | 2539 | 2351 | 2445 |
| Mean | 2579 | 2421 | |
| Critical difference between two B means (P=0.05) = 73 | | | |
| Critical difference between two C means (P=0.05) = 74 | | | |
| Interaction (B × C) | = Not significant | | |
| CV % | = 5.02 | | |

**Cultivation × Organic Matter**

| Organic Matter (C) / Cultivation (A) | Weeds & Pruning litters left | Weeds & Pruning litters removed | Mean |
|---|---|---|---|
| Sickling | 2603 | 2412 | 2508 |
| Cheeling | 2516 | 2363 | 2439 |
| Light hoeing | 2618 | 2488 | 2553 |
| Mean | 2579 | 2421 | |
| Critical difference between two A means (P=0.05) = 90 | | | |
| Critical difference between two C means (P=0.05) = 74 | | | |
| Interaction (A × C) | = Not significant | | |
| CV % | = 5.02 | | |

In the herbicide treated plots sickling produced significant increase in yield over cheeling. In no herbicide plots, however, light hoeing yielded significant crop over sickling and cheeling. The herbicide treated plots significantly increased the crop over no herbicide plots. This trial has again confirmed that the treatment of leaving the organic matter i.e. weeds and pruning litters at site definitely increased crop over those from where these were removed.

## 3. New Long-term Trial of different varieties at Nagrakata Head Quarter (D.62)

This experiment was conducted in the Dooars (Nagrakata HQ) to compare the yields from 15 different clones planted in 1973. The results for the years 1977 & 1978 are presented in Table 2.09.

In 1977, TV.19 produced the highest yield over the other clones except TV.18 and 107/16.

In 1978, clone TV.19 produced the highest crop over all the other clones. TV.19 was followed by clones TV. 20, TV.17, B/5/63 & TV.18, which had no significant difference amongst them.

**Table 2.09.** *Yield KMTH of 1977 & 1978 from different varieties*

| Sl. No. | Variety | 1977 (DS) | 1978 (UP) |
|---|---|---|---|
| 1. | ST. 203 | 2119 | 1555 |
| 2. | TV.1 | 2264 | 2338 |
| 3. | TV.9 | 2526 | 2341 |
| 4. | TV.17 | 2828 | 2825 |
| 5. | TV.18 | 3044 | 2758 |
| 6. | TV.19 | 3228 | 3232 |
| 7. | TV.20 | 2180 | 2910 |
| 8. | 107/2 | 2543 | 2527 |
| 9. | 107/16 | 3116 | 2632 |
| 10. | 107/17 | 2589 | 1462 |
| 11. | 19/48/16 | 2462 | 1629 |
| 12. | 338/1 | 1928 | 2515 |
| 13. | 356/3 | 2421 | 2658 |
| 14. | B/5/63 | 2482 | 2764 |
| 15. | 6/8 | 1562 | 2641 |
| | Critical difference for treatment (P = 0.05) | 396 | 311 |
| | CV % | 11.16 | 8.37 |

## 4. Young Tea Manuring (Experiment No. As. 145 & D.66)

Two experiments on young tea manuring, one each in Meleng Tea Estate (As.145) planted in autumn 1976 and Nagaisurie Tea Estate (D.66) planted in spring 1977, were initiated in 1977. The object of these experiments was to find out a suitable dose and frequency of YTD application in bringing up young tea. The results for the year 1978 are presented in Table 2.10.

The yield variation in different treatments did not reach statistical significance.

**Table 2.10.** *Yield in 1978 of young tea KMTH with differential manuring*

| Doses of YTD in gm/bush 6 to 8 weeks interval | As.145 (Meleng TE) Planted. 1976 | D.66 (Nagaisurie TE) Planted 1977 | Remarks |
|---|---|---|---|
| $T_1$ = 20 + 20 | 1146 | 158 | D.66-Yield from 9 plucking rounds only |
| $T_2$ = 13.3 + 13.3 + 13.3 | 1260 | 188 | |
| $T_3$ = 10 + 10 + 10 + 10 | 1271 | 152 | |
| $T_4$ = 30 + 30 | 1150 | 184 | |
| $T_5$ = 20 + 20 + 20 | 1191 | 160 | |
| $T_6$ = 15 + 15 + 15 + 15 | 1368 | 141 | |
| $T_7$ = 40 + 40 | 1276 | 177 | |
| $T_8$ = 27 + 27 + 27 | 1390 | 151 | |
| $T_9$ = 20 + 20 + 20 + 20 | 1303 | 162 | |
| $T_{10}$ = 50 + 50 | 1123 | 168 | |
| $T_{11}$ = 33.3 + 33.3 + 33.3 | 1326 | 163 | |
| $T_{12}$ = 25 + 25 + 25 + 25 | 1222 | 165 | |
| $T_{13}$ = 60 + 60 | 1121 | 174 | |
| $T_{14}$ = 40 + 40 + 40 | 1318 | 178 | |
| $T_{15}$ = 30 + 30 + 30 + 30 | 1294 | 165 | |
| Treatment difference | Not significant | Not significant | |
| CV % | 11.22 | 11.50 | |

## 5. Bringing up of young tea (D.70)

This experiment was conducted at Haldibari TE in the Dooars in 1977 in a TV.1 section, planted in July 1977, to find out the most suitable and economic method of development of young tea and to find out the effect of such development of final yield. The results of 1978 are presented in Table 2.11.

**Table 2.11.** *Effect of different methods of bringing up young tea planted in 1977 July, on yield KMTH in 1978*

| Treatments | Yield |
|---|---|
| $T_1$ = Cut across at 35 cm from the ground. Centre out between 10-15 cm leaving 2-3 side laterals, pluck at 50 cm. Frame forming prune after 12-18 months. Then follow step up plucking. | 1240 |
| $T_2$ = Cut across at 35 cm from the ground and centre out between 10-15 cm. Pluck at 50 cm. Follow step up plucking for two seasons and then review. | 1280 |
| $T_3$ = Pegging-follow step up plucking initiating from 40 -45 cm. Cut across at 35-40 cm after one full season and light centre clean out. Then follow step up plucking. | 1424 |
| $T_4$ = Centre out between 10-15 cm leaving 2-3 side laterals-pegged. Follow step up plucking initiating from 40-45 cm for one full season and then review. | 1196 |
| Critical difference for two treatment means (P = 0.05) | 129 |
| CV % | 7.27 |

During 1978, pegging ($T_3$) produced the highest crop while the other treatments were not significantly different in yield.

## 6. Rejuvenation Experiment

### (i) Assam North Bank Experiments (An 135,) An. 136 & An. 137)

Three experiments, one each in Kacharigaon (An.135), Tezpur & Gogra (An.136) and Baghmari (An-137) Tea Estates, were laid out during 1974. The results for 1978 are presented in Table 2.12.

At Kacharigaon (An.135) and Baghmari (An.137) Tea Estates, cold weather pruning, in general, was superior to rains pruning while in Tezpur & Gogra(An.136) July/August pruning increased yield over cold weather pruning. In all these experiments, different treatments did not yield higher than control as presumably the infills did not start contributing fully towards higher production.

### (ii) Dooars (West Bengal) D.43, D.44, D.45, & D.46

Four experiments, one each in Dalgaon ( D.43 ), Matelli (D.44), Killcott (D.45) and Rydak ( D.46 ) Tea Estates were laid out during 1972. The results for 1978 are presented in Table 2.13.

**Table 2.12.** *Effect of Rejuvenation treatments on yield KMTH in 1978*

| Treatments | An.135 (Kachari-gaon TE) | An.136 Tezpur & Gogra TE) | An.137 (Bagmari Tea Estate) |
|---|---|---|---|
| $T_1$ — No rejuvenation (control) | 1166 | 814 | 2196 |
| $T_2$ — Cold weather prune, and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one | 39 | 660 | 2016 |
| $T_3$ — Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original spacing was 150 cm × 150 cm, make it into 150 cm × 75 cm. | 792 | 693 | 2012 |
| $T_4$ — Prune in July/August and infill in the autumn as in $T_2$ | 740 | 708 | 1873 |
| $T_5$ — Prune in July/August and infill in the autumn as in $T_3$ | 802 | 768 | 1930 |
| Critical difference for two treatment means (P = 0.05) | 183 | Not Significant | 177 |
| CV % | 7.60 | 10.78 | 3.18 |

Higher yields were obtained from cold weather pruning for rejuvenation over rains pruning at all places in the Dooars except in Matelli Tea Estate (D.44).

In Dalgaon TE (D.43), cold weather prune for rejuvenation with interplanting produced substantial increase in yield over other treatments, but this increase in yield was not statistically significant.

All the experiments except D.43 showed that when the bushes were pruned during cold weather no beneficial increase in yield was obtained from interplanting. On the contrary, when the bushes were pruned in the rains, interplanting was more beneficial for increased crop.

**Table 2.13.** *Effect of time of pruning for rejuvenation and infilling method on Yield KMTH in 1978*

| Treatments | D.43 (Dalgaon TE) | D.44 (Matelli TE) | D.45 (Killcott TE) | D.46 (Rydak TE) |
|---|---|---|---|---|
| $T_1$ — No rejuvenation (control) | 1565 | 1709 | 2329 | 1488 |
| $T_2$ — Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one | 1997 | 1609 | 2402 | 2109 |
| $T_3$ — Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge i.e. if the original spacing was 150 cm × 150 cm, make it in to 150 cm × 75 cm. | 2590 | 1592 | 2330 | 2281 |
| $T_4$ — Prune in July/August and infill in the autumn as in $T_2$ | 1996 | 1691 | 2261 | 1880 |
| $T_5$ — Prune in July/August and infill in the autumn as in $T_3$ | 2167 | 1932 | 2254 | 2192 |
| Critical difference for two treatment means | Not significant | 181 | Not significant | 243 |
| CV % | 10.89 | 2.39 | 3.34 | 4.40 |

## 7. Micronutrient Trials

During 1978 ten commercial micronutrients and fourteen other Tocklai formulations were tried at 31 sites in different agro-climatic regions of North-East India.

The first year results have been variable. In unpruned tea, it was observed that the different treatments increased crop over control and this increase in yield was variable and ranged between 3 and 39 per cent. Similarly, in pruned and deep skiffed tea the increase in yield over control was also observed and this increase ranged between 5 and 45 per cent. But neither a single commercial product nor any Tocklai formulations gave consistent increase at all sites.

In another set the increase due to Chelated zinc and zinc sulphate over control varied from marginal i.e. 2.3% to as high as 41% in unpruned tea. In pruned and deep skiffed tea the increase varied between 5 and 26 per cent. Chelated zinc could not prove itself to be superior to non-chelated form in these estate trials.

The trials are now continuing.

## Highlights

*Cessation/reduction of nitrogen caused reduction in yield in the second and third year. Application of phosphorus increased yields. Drip irrigation increased both early and total crop. Leaving a leaf in mid-April in unpruned tea increased yield. Coarse plucking and plucking on longer rounds gave higher yields of poorer quality. Autumn application of preemergence herbicides was as effective as normal spring application. Solubilization of glyphosate improved its efficacy for control of* Imperata. *Herbicide spraying with WFN 62 nozzle was less efficient than with WFN 40 nozzle.*

### Plant Nutrition

Several experiments are being conducted at Borbhetta and Tocklai Division to study the response of tea to different plant nutrients. The results of some of these experiments are briefly discussed below.

### Nitrogen

A factorial experiment (B.8/1) was initiated in 1966 with three nitrogen levels (100, 200 and 300 kg/ha) and two clones ( TV 1 and TV 9 ) besides four spacings. Basal dose of 50 kg $P_2O_5$ and 100 kg $K_2O$ per ha was applied to all the treatments. Although there was no yield difference between treatments in 1970, 200 and 300 kg levels, which were at par, were significantly superior to 100 kg level in 1971 and 1972. In 1973, 300 kg level reduced the yield markedly. This deleterious effect was significant (when compared with 100 kg and 200 kg levels) since 1974 (Table 3.01). Yield reduction due to continuous application of 300 kg N over 100 kg level ranged from 13 per cent in 1973 to 53 per cent in 1977; it was 23 per cent in 1978. This significant adverse effect was also observed at 200 kg in 1976 and 1977 but not in 1978.

**Table 3.01**. *Effect of different levels of nitrogen on yield of clonal tea (made tea, kg/ha)*

| Nitrogen (kg/ha) | 1973 L.P. | 1974 D.S. | 1975 M.S. | 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|---|---|
| 100 | 1484 | 1990 | 1897 | 1964 | 1672 | 1836 |
| 200 | 1544 | 2060 | 2028 | 1633 | 1305 | 1945 |
| 300 | 1289 | 1659 | 1565 | 1125 | 784 | 1417 |
| L.S.D. (at 5% level) | N.S. | 226 | 200 | 184 | 199 | 218 |
| C.V. (%) | 22.1 | 16.1 | 14.0 | 16.0 | 21.6 | 17.0 |

In another experiment (B.104), the effect of three levels of nitrogen (90, 135 and 180 kg/ha) on two *jats* ( Betjan and Gaurishankar ) of tea planted at five spacings is being studied. After an initial boost in yield in 1961, the higher levels of nitrogen tended to depress the yield from 1969. When compared with 90 and 135 kg levels, 180 kg N level reduced the yield significantly in all the years from 1969 to 1978. In all years, except 1974 and 1977, 90 kg level gave significantly higher yield over 135 kg level (Table 3.02).

**Table 3.02**. *Effect of three levels of nitrogen on the yield of jat tea (made tea, kg/ha).*

| Nitrogen (kg/ha) | 1972 L.P. | 1973 D.S. | 1974 M.S. | 1975 M.P. | 1976 U.P. | 1977 L.P. | 1978 D.S. |
|---|---|---|---|---|---|---|---|
| 90 | 1462 | 1289 | 1361 | 596 | 1875 | 1289 | 1504 |
| 135 | 1370 | 1174 | 1343 | 540 | 1764 | 1234 | 1412 |
| 180 | 1276 | 1117 | 1251 | 481 | 1591 | 1133 | 1280 |
| L.S.D. (at 5% level) | 59 | 50 | 56 | 31 | 87 | 62 | 74 |
| C.V. (%) | 9.6 | 9.4 | 9.6 | 13.0 | 11.1 | 11.4 | 11.1 |

In a different factorial experiment under unshaded condition (B.5.1), the response of Tingamira *jat* tea to four levels of nitrogen (0, 50, 100 and 150 kg/ha) along with two levels each of phosphorus and potassium is being studied since 1961. As in the past, there was significant yield response to 50 kg level in 1978 also. But when this level was raised to 100 kg, there was significant yield reduction in 1972, 1973, 1977 and 1978 (Table 3.03).

A further raise in nitrogen level to 150 kg depressed the yield further significantly. This reduction in yield which ranged from 12 to 43 per cent (compared to yield at 50 kg level) was first noticed in 1969 and continued every year thereafter.

**Table 3.03**. *Effect of different levels of nitrogen on the yield of unshaded jat tea (made tea, kg/ha)*

| Nitrogen (kg/ha) | 1972 L.P. | 1973 U.P. | 1974 U.P. | 1975 L.P. | 1976 U.P. | 1977 D.S. | 1978 L.P. |
|---|---|---|---|---|---|---|---|
| 0 | 1134 | 1153 | 1234 | 798 | 1353 | 993 | 919 |
| 50 | 1348 | 1522 | 1765 | 1160 | 2076 | 1372 | 1341 |
| 100 | 1148 | 1434 | 1808 | 1093 | 2091 | 1274 | 1143 |
| 150 | 854 | 1135 | 1549 | 819 | 1786 | 1001 | 760 |
| L.S.D. (at 5% level) | 87 | 88 | 109 | 88 | 145 | 95 | 89 |
| C.V. (%) | 10.9 | 9.4 | 9.6 | 12.7 | 11.2 | 10.5 | 11.9 |

### Effect of cessation/reduction of nitrogen

In an experiment (B. 113.1) where the effects of single Vs split application of 90 and 135 kg N/ha were studied on *jat* (Khorijan planted in 1960) tea from 1965 to 1975, no significant differences between treatments were observed. In 1976, these seven treatments were modified to include a new set of treatments where nitrogen application was either withheld or applied at the same or lower levels.

The results of 1976 showed that there was no significant yield reduction as result of withholding nitrogen or reducing the level of nitrogen (Table 3.04).

**Table 3.04.** *Effect of cessation/reduction of nitrogen on the yield of tea*

| Nitrogen level (kg/ha) from 1965 to 75 | Nitrogen level kg/ha) from 1976 | Made tea (kg/ha) 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|
| 90 no split | 90 | 1655 | 1964 | 1920 |
| 90 two splits | 45 | 1552 | 1770 | 1801 |
| 90 four splits | 0 | 1478 | 1571 | 1552 |
| 135 no split | 135 | 1538 | 1909 | 1850 |
| 135 three splits | 90 | 1539 | 1754 | 1713 |
| 135 two splits | 45 | 1539 | 1693 | 1670 |
| 135 four splits | 0 | 1522 | 1553 | 1488 |
| L.S.D. (5% level) | | N.S. | 204 | 223 |
| C.V. (%) | | 4.5 | 6.6 | 7.3 |

However, ceasing nitrogen application in 90 kg (two splits) and 135 kg (four splits) or lowering it from 135 kg (two and three splits) to 45 and 90 kg resulted in significant reduction in yield in 1977 and 1978. There was no significant yield difference between 90 kg and 135 kg levels.

## Phosphorus

One factorial experiment (B.105) is being conducted since 1960 to study the response of TV 2 clone to four levels of $P_2O_5$ (along with four levels of potash) applied as single superphosphate at a constant rate of 90 kg/ha N upto 1971 and 135 kg/ha from 1972. After an initial adverse effect at 180 kg till 1970 and no significant response from 1971 to 1973, phosphorous was found to increase yield significantly in 1974, 1976, 1977 and 1978 (Table 3.05). There was significant response to phosphorous at 90 kg in 1974, 1976 and 1977 and 1978 and at 45 kg in 1976, 1977 and 1978. There was no significant yield increase above 45 kg level in 1974, 1977 and 1978. However, in 1976, 90 kg level was significantly superior to 45 kg level. Application of 180 kg appeared to be detrimental in all years except 1976.

**Table 3.05.** *Effect of different levels of phosphorus on yield of tea (made tea, kg/ha).*

| $P_2O_5$ (kg/ha) | 1974 D.S. | 1975 L.S. | 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|---|
| 0 | 1865 | 1786 | 1022 | 1348 | 1440 |
| 45 | 1977 | 1824 | 1231 | 1631 | 1657 |
| 90 | 2067 | 1826 | 1410 | 1645 | 1648 |
| 180 | 1975 | 1711 | 1446 | 1599 | 1591 |
| L.S.D. (5% level) | 117 | N.S. | 139 | 175 | 165 |
| C.V. (%) | 8.4 | 11.7 | 15.3 | 15.8 | 14.6 |

## Potassium

The response of clonal tea (TV 2) to potassium is being studied since 1960 in an experiment (B.105) involving four levels of $K_2O$ (0, 45, 90 and 180 kg/ha) and four levels of $P_2O_5$ (discussed under response to phosphorus) at a constant rate of 90 kg/ha of N upto 1971 which was raised to 135 kg/ha from 1972. There was significant response to $K_2O$ upto 45 kg/ha from 1970 to 1978 (Table 3.06). Although there was no significant yield difference between 45 kg and 90 kg levels in any of the years except 1977, the 180 kg level gave significantly higher yield over 45 kg/ha in all the skiffed years (1971, 1972, 1974, 1975, and 1977) as well as the unpruned year (1978).

**Table 3.06.** *Effect of different levels of potassium on the yield of tea (made tea, kg/ha).*

| $K_2O$ (kg/ha) | 1970 L.P. | 1971 D.S. | 1972 M.S. | 1973 L.P. | 1974 D.S. | 1975 L.S. | 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1279 | 1490 | 2289 | 1495 | 1671 | 1555 | 1049 | 1281 | 1234 |
| 45 | 1530 | 1708 | 2555 | 1779 | 1988 | 1780 | 1293 | 1293 | 1585 |
| 90 | 1596 | 1810 | 2652 | 1803 | 2054 | 1880 | 1349 | 1687 | 1709 |
| 180 | 1625 | 1913 | 2803 | 1854 | 2171 | 1933 | 1420 | 1793 | 1808 |
| L.S.D. 5% level | 109 | 126 | 167 | 106 | 117 | 149 | 139 | 175 | 165 |
| C.V. (%) | 10.2 | 10.2 | 9.1 | 8.6 | 8.4 | 11.7 | 15.5 | 15.8 | 14.6 |

## Nitrogen × Potassium interaction

In the experiment B.5.1, where shade was absent, the interaction between nitrogen and potassium was significant in all the years since 1972. At every level of nitrogen (50 to 150 kg/ha), addition of 100 kg $K_2O$/ha resulted in significant increase in yield in all the years including 1976, 1977 and 1978 (Table 3.07).

**Table 3.07.** *Effect of nitrogen in the presence and absence of potassium on yield (made tea, kg/ha)*

| $K_2O$ kg/ha | 1976 | (U.P.) | 1977 | (D.S.) | 1978 | (L.P.) |
|---|---|---|---|---|---|---|
| Nitrogen kg/ha | 0 | 100 | 0 | 100 | 0 | 100 |
| 0 | 1359 | 1346 | 1034 | 952 | 982 | 856 |
| 50 | 1895 | 2257 | 1241 | 1502 | 1193 | 1489 |
| 100 | 1720 | 2192 | 1058 | 1490 | 900 | 1386 |
| 150 | 1395 | 2176 | 747 | 1254 | 489 | 1020 |
| L.S.D. (at 5% level) | 206 | | 135 | | 126 | |
| C.V. (%) | 11.2 | | 11.2 | | 10.5 | |

The deleterious effect of higher levels of nitrogen (100 and 150 kg/ha) was significantly alleviated in the presence of $K_2O$. The $N_{50}$ $K_{100}$ and $N_{100}$ $K_{100}$ levels gave significantly higher yields in all the years.

This interaction was not significant under shade.

## Zinc and other Micronutrients

A new trial (T/2) was initiated in 1978 to study the response of *jat* tea (planted in 1957) to different micronutrients such as zinc (Zn) applied as Zinc sulphate, boron as boric acid, magnesium as magnesium sulphate, manganese as manganese sulphate and molybdenum as molybdic acid alone and in combinations of Zn+B+Mg+Mn, Bo+Mg+Mn+Mo, Zn+Mg+Mn+Mo, Zn+B+Mn+Mo, Zn+B+Mg+Mo and Zn+B+Mg+Mn. A plant growth regulator, naphthalene acetic acid was also being studied alone and in combination with Zinc.

The results indicated that there were no significant yield differences between treatments. The trial is continued.

**Commercial Formulations of Micronutrients**

Another experiment (T/3) was initiated in 1978 to study the effect of different commercial formulations of micronutrients on the yield of clonal tea (Cinnamara Clone) planted in 1957.

The results are inconclusive and the trial is continued.

**Irrigation**

A drip irrigation (or trickle irrigation) system was installed in December 1977 to study its feasibility in tea. It involves slow application or controlled release of water to crop root zone. This is done by using PVC tubing along the crop row with small nozzles or emitters provided near each plant. Water is pumped through the plastic pipes and it drips through the emitters. This system economises the use of water considerably.

An experiment on drip irrigation was laid out on mixed clonal tea planted in 1973. The three treatments included were (i) drip irrigation alone (ii) drip irrigation with 100 kg N/ha as urea plus 100 kg $K_2O$/ha as muriate of potash applied once along with irrigation water on 16-2-1978, and (iii) no irrigation. In drip irrigation alone and control plots 100 kg N and 100 kg $K_2O$ were broadcast on the ground in April, 1978. Tensiometers were installed at 22 cm, 45 cm, 60 cm and 90 cm depths in one replication. Irrigation was started in January 1978 and repeated whenever the tensiometer show 10 cm mercury reading.

**Table 3.08.** *Effect of drip irrigation on the yield of unpruned tea*

| Year | Month | Made tea (kg/ha) Control (Normal fertilizer application) | Drip irrigation | Drip irrigation with fertilizer |
|---|---|---|---|---|
| 1978 | March | 106 | 216 | 282 |
| | April | 179 | 199 | 221 |
| | May | 232 | 406 | 380 |
| | June | 298 | 338 | 334 |
| | July | 348 | 405 | 394 |
| | August | 409 | 405 | 394 |
| | September | 456 | 488 | 456 |
| | October | 437 | 442 | 426 |
| | November | 193 | 198 | 203 |
| | Total in 1978 | 2658 | 3046 | 3052 |
| | % increase over control | | 14.6 | 14.8 |

Drip irrigation caused a substantial increase in the early crop (Table 3.08). There was 14.6 per cent increase in total crop in 1978 due to drip irrigation. Addition of fertilizer with drip irrigation was at par with normal soil application of fertilizer followed by drip irrigation.

**Plucking**

In 1976, the plucking experiment (B.112.1) was modified to study the effect of continuous and intermittent standard and back plucking systems. The plucking season was divided into three periods i.e. beginning of the season to May, June to September, and October to November. Standard (St) and/or black (Bl) plucking in these three periods were done continuously or intermittently in various combinations. There was no significant yield difference between these treatments in 1976 and 1977, the first and second year of the experiment.

**Table 3.09.** *Effect of different combinations of standard and black plucking at various plucking periods on the yield of tea in 1978*

| Plucking treatments at various periods of plucking. | | | Yield (made tea, kg/ha at different plucking periods in 1978 (L.P.) | | | Total |
|---|---|---|---|---|---|---|
| Early | Main | Late | Early upto May | Main June-Sept. | Late Oct-Nov. | |
| Bl | Bl | Bl | 115 | 1189 | 464 | 1768 |
| Bl | Bl | St | 102 | 1128 | 568 | 1798 |
| Bl | St | St | 97 | 1402 | 495 | 1994 |
| Bl | St | Bl | 82 | 1381 | 443 | 1906 |
| St | St | St | 96 | 1302 | 472 | 1870 |
| St | St | Bl | 115 | 1406 | 449 | 1970 |
| St | Bl | Bl | 92 | 1133 | 449 | 1674 |
| St | Bl | St | 88 | 1175 | 504 | 1767 |
| L.S.D. (at 5% level) | | | — | — | — | 198 |
| C.V. (%) | | | | | | 6.1 |

Data of 1978 indicated (Table 3.09) that in the year of prune black plucking till May followed by standard plucking gave the highest yield. This treatment was at par with all except three treatments *viz.*,continuous black plucking, standard plucking in the early part followed by black plucking for the rest of the year, and standard plucking in the early part and back end and black plucking in the main season. This is contrary to the earlier results where no difference was found between black and standard plucking. These differences have possibly been caused due to the cumulative effect of these two systems of plucking and bring out the deleterious effect of black plucking particularly in the main season.

Two new experiments (T/7 and T/8) were initiated in 1978 to study the effect of different plucking methods in young clonal tea planted in 1970-71 and mixed *jats* of tea planted in 1925 in Tocklai Division. Both experimental areas had shade of *Albizzia odoratissima.*

The results (Table 3.10) showed that in both types of tea there was no significant difference between plucking standard throughout the year ($T_1$) and plucking standard and leaving a leaf in mid-April ($T_2$). In clonal tea these two treatments were significantly superior to standard plucking and raising a leaf in June/July ($T_3$) and tipping over one leaf followed by standard plucking throughout the year ($T_4$). In *jat* tea, however, these two treatments gave significantly higher yield over $T_4$.

In another new trial (T/5) the effect of black, standard and coarse plucking was studied with janam, fish leaf and step up plucking on clonal tea (33/52) planted in 1967 (Table 3.11).

**Table 3.10.** *Effect of different plucking methods on yield of clonal as well as mixed jats of tea. (Early crop is shown in brackets)*

| Treatment | Made tea (kg/ha) 1978 UP | |
|---|---|---|
| | Clonal tea | Jat tea |
| $T_1$ Standard over janam | 2949 (972) | 1734 (536) |
| $T_2$ Standard over janam + 1 leaf up in mid-April | 3066 (1031) | 1750 (542) |
| $T_3$ Standard over janam + 1 leaf up in June/July | 2511 (1001) | 1566 (449) |
| $T_4$ Tip over one leaf, than standard over janam throughout the year | 2625 (710) | 1446 (393) |
| L.S.D. (at 5% level) | 159 | 237 |
| C.V. (%) | 4.4 | 11.9 |

**Table 3.11.** *Effect of different plucking standards and systems on yield of clonal tea*

| Plucking Treatment | Made tea (kg/ha) 1978 (D.S.). | Mean % fine leaf |
|---|---|---|
| Janam-black | 1786 | 75 |
| Janam-standard leaving 1 bud | 1997 | 60 |
| Janam-coarse leaving 2 and a bud | 2333 | 44 |
| Fish-black | 1885 | 75 |
| Fish-standard leaving 1 and a bud | 1870 | 62 |
| Fish-coarse leaving 2 and a bud | 2063 | 45 |
| Janam + 1 step up in July & pluck black | 1646 | 70 |
| Janam + 1 step up in July & pluck standard | 1820 | 61 |
| Janam + 1 step up in July & pluck Coarse leaving 2 and a bud | 2268 | 45 |
| L. S. D. (at 5% level) | 162 | |
| C. V. (%) | 4.6 | |

Coarse plucking to janam gave the highest yield. Stepping up by a leaf in July reduced yield though not significantly. Coarse plucking over fish leaf gave significantly lower yield. Between standard and black plucking treatments, the standard over janam treatment gave the highest yield. Black plucking tended to depress yield except in the fish leaf system. The leaf was finer in the black plucking treatments than standard or coarse plucking treatments. Stepping up in July also tended to depress yield.

Another new trial (T/4) was initiated on clonal tea planted in 1967 to study the effect of frequency of plucking on yield. The experimental area had *Albizzia odoratissima* shade.

**Table 3.12.** *Effect of frequency of plucking on yield of clonal tea*

| Plucking frequency | Made tea (kg/ha) 1978 (D.S.) |
|---|---|
| 5- day round | 2390 |
| 7- day round | 2567 |
| 9- day round | 3063 |
| 11 day round | 2966 |
| 13- day round | 3473 |
| L.S.D. (5% level) | 233 |
| C.V. (%) | 5.2 |

The results showed that 13-day round gave significantly highest yield over all other treatments (Table 3.12). There was no significant difference between 5-day and 7-day rounds, but they gave significantly lowest yield when compared to other treatments. There was no significant difference between 9-day and 11-day rounds.

## Longterm yield trial of Tocklai clones

A long term yield trial (B.40/1) was initited in 1966-67 with different clones to compare their yield performance under *Indigofera teysmanii* shade. In the light prune year of 1978. TV19 gave the highest yield and it was at par with TV 14, TV 16, and TV 11 (Table 3.13). It is interesting to note that this clone gave the highest yield in the light prune year of 1976 also. In the unprune year of 1977, TV 17 gave the highest yield, but in 1978 it ranked 7th. Clone TV 2 gave the lowest yield and second lowest yield in the light pruned years of 1976 and 1978 respectively and third lowest yield in the unpruned year of 1977. This suggests the possibility of interaction of clone and type of pruning.

**Table 3.13.** *Yield of different clones and seed stocks (made tea, kg/ha)*

| Clone | 1976 L.P. | 1977 U.P. | 1978 L.P. | Clone | 1976 L.P. | 1977 U.P. | 1978 L.P. |
|---|---|---|---|---|---|---|---|
| TV 1 | 1653 | 1960 | 1791 | TV 13 | 1855 | 2223 | 1365 |
| TV 2 | 1360 | 2009 | 1269 | TV 14 | 1890 | 2703 | 2045 |
| TV 4 | 1719 | 2433 | 1850 | TV 15 | 1680 | 2431 | 1656 |
| TV 7 | 1669 | 2013 | 1471 | TV 16 | 1914 | 2410 | 2002 |
| TV 6 | 1463 | 1740 | 1104 | TV 17 | 1859 | 3028 | 1892 |
| TV 8 | 1594 | 2440 | 1588 | TV 18 | 1905 | 2716 | 1894 |
| TV 9 | 1748 | 2270 | 1907 | TV 19 | 2231 | 2614 | 2262 |
| TV 10 | 1896 | 2947 | 1864 | 107/2 | 1717 | 2489 | 1892 |
| TV 11 | 1855 | 2679 | 1983 | Stock 450 | 1686 | 2357 | 1759 |
| TV 12 | 1739 | 2654 | 1702 | Betjan | 1590 | 2296 | 1619 |
| L.S.D. (5% level) | 308 | 380 | 333 | | 308 | 380 | 333 |
| C.V. (%) | 12.4 | 11.1 | 13.5 | | 12.4 | 11.1 | 13.5 |

Clones which gave relatively poor response to unprune in 1977 were TV 1, TV 7, TV 6, TV 9, TV 13, TV 16 and TV 19.

## Planting and Spacing

One factorial experiment (B.8/1) was initiated in 1966 with four plant-to-plant spacings (90 cm, 45 cm, 30 cm and 22.5 cm) at a constant row spacing of 120 cm, three nitrogen levels (100, 200 and 300 kg/ha) and two clones (TV 1 and TV 9).

**Table 3.14.** *Effect of different spacings on yield of clonal tea (made tea, kg/ha).*

| Spacing (cm) | Plant Population/ha | 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|
| 120 × 90.0 | 9,260 | 1333 | 1037 | 1451 |
| 120 × 45.0 | 18,520 | 1524 | 1180 | 1691 |
| 120 × 30.0 | 27,780 | 1562 | 1293 | 1819 |
| 120 × 22.5 | 37,040 | 1875 | 1519 | 1965 |
| L.S.D. (at 5% level) | | 212 | 204 | 266 |
| C.V. (%) | | 16.0 | 19.0 | 17.0 |

The closest spacing of 120 cm × 22.5 cm gave significantly higher yields than all other spacings in 1976 and 1977. In 1978 also this spacing gave significantly higher yield over 120 cm × 45 cm and 120 cm × 90 cm spacings. The 120 cm × 22.5 cm and 120 cm × 30 cm spacings were significantly superior to the widest spacing of 120 cm × 90 cm.

Another experiment (B.8/2), also started in 1966 with Khorijan tea, has six plant-to-plant spacings (120 cm, 90 cm, 75 cm × 75 cm, and doubletons at 90 cm and 75 cm) with a constant row spacing of 120 cm.

**Table 3.15.** *Effect of different spacings on the yield of jat (Khorijan) tea (made tea, kg/ha)*

| Spacing (cm) | Plant Population /ha | 1976 L.P. | 1977 D.S. | 1978 U.P. |
|---|---|---|---|---|
| 120×120 | 6,944 | 1219 | 1385 | 1615 |
| 120× 90 | 9,259 | 1255 | 1484 | 1658 |
| 120× 90 (doubleton) | 18,518 | 1380 | 1651 | 1759 |
| 120× 75 | 11,111 | 1208 | 1516 | 1774 |
| 120×75×75 | 13,675 | 1547 | 1719 | 1868 |
| 120× 60 | 13,888 | 1437 | 1656 | 1812 |
| L.S.D. (at 5% level) | — | 186 | 133 | 153 |
| C.V. (%) | — | 9.2 | 5.6 | 5.8 |

The 120 cm × 75 cm × 75 cm and 120 cm × 60 cm spacings which were at par gave significantly higher yield over the widest spacing of 120 cm × 120 cm in all three years (Table 3.15). The 120 cm × 75 cm × 75 cm spacing was significantly superior to 120 cm × 120 cm, and 120 cm × 90 cm spacing in 1978 and 120 cm × 120 cm, 120 cm × 90 cm and 120 cm × 75 cm spacings in 1976 and 1977. In none of the years the yield difference between 120 cm x 90 cm (doubleton) and 120 cm × 75 cm × 75 cm spacings was significant.

A systematic fan design experiment (B.32.2) was planted with TV 18 in July 1974 to include 23 spacings ranging from 15 cm to 150 cm. In 1976, the yield data were represented in the form of an asymptotic curve (vide Annual Report, 1976-77).

As yield estimates from closer spacings tend to get exaggerated due to smaller plot size and inadequate number of bushes per plot, the yield data were fit in the curve by eliminating seven close spacings in 1976 and 11 close spacings in 1977. This gave a parabolic yield population curve with yield declining beyond 67,997 plants/ha in 1976 (2 years after planting) and 23,208 plants/ha in 1977 (3 years after planting).

In 1978 also 11 close spacings have been eliminated and the data of the other 12 spacings were analyzed and used to draw the yield-population curve. The yield declined beyond 21,950 plants/ha in 1978 (4 years after planting) (Fig. 3.01). These results show that yield starts declining beyond a certain population. They also show that the decline sets in at a lower level of population with increasing age.

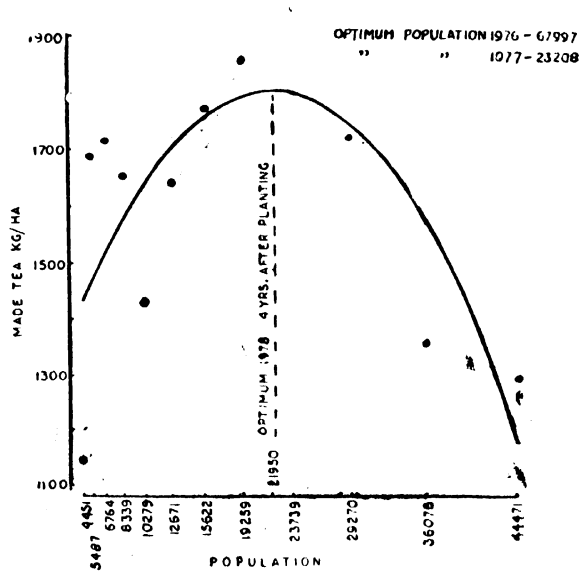



**Fig 3.01 — Yield pouplation curve for clone TV 19 in 4th year after planting.**

## WEED CONTROL

### Weed Competition in Young Tea

A field experiment is being conducted since April 1976 on an area planted with TV 18 in November 1975 to determine the critical period of weed competition in young tea. Weed control was done in certain periods of the year (c.f. Table 3.19 for treatments), and the plots were left unweeded in the remaining part of the year.

Weed control during the six-month period of April to September was critical and was as effective as maintaining the young tea weed free throughout the 12-month period (Table 3.16). It increased the yield of young tea over unweeded control by 193% in the first year, 355% in the second year and 232% in the third year. Even during this critical period of 6 months, weed control only during the first three months, April-July, reduced the yield by 50% in the first year as against a reduction of 41% by weed control in the later 3 months—July to September.

**Table 3.16.** *Effect of weed competition at different periods of the year on the yield of young tea*

| Weed control period | No. of months | Made tea 1977 kg/ha | 1977 % reduction | 1978 kg/ha | 1978 % reduction |
|---|---|---|---|---|---|
| April-September | 6 | 933 | — | 2430 | — |
| April-March | 12 | 925 | 1 | 2400 | 1 |
| April-June | 3 | 469 | 50 | 1633 | 33 |
| July-September | 3 | 546 | 41 | 1417 | 42 |
| October-March | 6 | 339 | 64 | 1154 | 53 |
| October-December | 3 | 269 | 71 | 836 | 66 |
| January-March | 3 | 252 | 73 | 876 | 64 |
| No weed control | — | 211 | 77 | 733 | 70 |

The cause of the adverse effect of weeds is evident from dry matter accumulation by weeds and nitrogen removal by them (Table 3.17). Weed growth during the critical period of 6 months April to September, was as high as during 9 months (April to December) of active growth. Further, nitrogen removal by weeds amounted to as much as 145 kh/ha during the critical period. Results show clearly that weed competition is critical during April to September when weed free situation must be maintained. Weed control for only a part of this critical period will have corresponding adverse effect on the productivity of young tea.

**Table 3.17.** *Amount of dry matter accumulation in various periods of the year (April 1978 to March 1979) and nitrogen removal*

| Weed infestation period | Duration (months) | Dry matter of weeds (kg/ha) | Nitrogen removal (kg/ha) |
|---|---|---|---|
| April-September | 6 | 8049 | 145.0 |
| October-March | 6 | 239 | 4.3 |
| January-September | 9 | 8395 | 151.0 |
| April-December | 9 | 8198 | 148.0 |
| July-March | 9 | 729 | 13.0 |
| October-June | 9 | 1781 | 32.0 |

## Autumn Application of Preemergence Herbicides

### Mature tea

In an experiment conducted in mature tea, the preemergence herbicides were applied in one half of the area, on clean ground on December 15, 1977 before light pruning on December 23, 1977. There was rain two days after herbicide application. The pruning crop litter remained on the ground. In the other half of the area, same herbicides were applied on the clean ground on March 29, 1978 which is the normal time of preemergence herbicides in spring. Before herbicide application, the pruning crop litter was carried out of the plots for proper ground cover with herbicide. After spraying, the litter was brought back to the plots and spread out uniformly.

The results presented in Fig. 3.02 on per cent ground coverage by weeds at different periods of the year indicated that the preemergence herbicides were as effective when applied in autumn as in the normal spraying season. There is no apparent reduction in their weed control efficacy when spraying was done even five months before the normal time.

Of the various herbicides tested, diuron was more effective and had longer duration of activity, weed control was more efficient at 2 kg/ha. The weed control efficiency of 2 kg/ha level of simazine and 1 kg/ha level of diuron were identical. Butachlor either as emulsifiable concentrate or as granular formulation was less efficient.

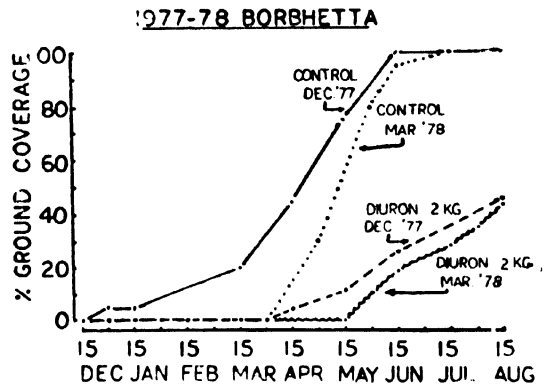



**Fig 3.02. Effect of spring and autumn application of diuron on weed control.**

### Non-tea area

In a similar study in non-tea area, diuron and simazine were applied in the first week of December (1977) at 0.5, 1.0 and 2.0 kg/ha and the EC and GR formulations of butachlor at 1.0 and 2.0 kg/ha.

The data indicated that at 2.0 kg/ha, diuron gave 80% control of broadleaf weeds 4½ months after application (third week of April 1978) and its efficacy was reduced to 46% at the end of 6 months (first week of June). At equal rates, simazine was less persistent than diuron. Butachlor was even much less persistent. There was little difference in the activity of EC and GR formulations of butachlor.

## Granular Formulation of Herbicides

Two experiments were conducted between April and July to determine the relative efficacy of preemergence control of annual weeds (mostly *Borreria hispida*) by EC and GR formulations of alachlor and butachlor in comparison with wettable powder (WP) formulations of simazine and diuron. All herbicides were tried at 2 kg/ha.

The results of both trials showed that there was little difference in the preemergence weed control of alachlor and butachlor and between their EC and GR formulations. Nitrofen granules were less effective than alachlor and butachlor granules. However, diuron and simazine were more effective than these new herbicides.

# HERBICIDE TOXICITY ON TEA

## 1. Tolerance of young tea to Glyphosate

Two field trials were conducted to study the tolerance of young tea of TV 1 (2-years old) and TV 18 (3-years old) to different rates (0.4, 1.2 and 2.0 kg/ha) of glyphosate.

When glyphosate was applied on top of the bushes, flushing was severely inhibited in both clones; but TV 1 recovered from the set back caused by 0.4 kg/ha rate faster than TV 18. At 1.2 and 2.0 kg/ha, toxicity was more severe in both clones.

Nondirected spraying, resulting in part of spray reaching the sides of the bush, of glyphosate caused no effect on TV 1 flush even at 2.0 kg/ha. In case of TV 18, there was a slight set back at 2.0 kg/ha for only the first one month.

**2. Mitigation of diuron injury on young tea**

Preliminary field trials conducted on this aspect indicated that when activated carbon (20 kg/ha) was mixed as slurry in diuron (3 kg/ha) solution and applied to soil at preemergence, the efficacy of the herbicides and its toxicity on young tea (TV 18) were substantially less than when diuron was applied alone.

## CONTROL OF MIXED WEED

A large scale field trial was conducted in non-cropped area infested with several perennial grasses like *Imperata cylindrica, Panicum sp., Paspalum sp., Arundinella bengalensis,* and *Saccharum spontaneum* which accounted for 40%, 25%, 15%, 10% and 10% of the grass infestation respectively.

At 0.8 kg/ha, glyphosate controlled (at the end of 12 weeks) *Imperata* to the extent of 80%, *Panicum* 90% and *Paspalum* 85% (Table 3.18). At this rate, its effect on *Saccharum* and *Arundinella* was only moderate. But 2 kg/ha controlled these two perennial grasses effectively (88 to 98%).

The tank mix of diuron with glyphosate reduced the effect of the latter on *Paspalum* and *Arundinella* but markedly enhanced it on Panicum. Similarly, 2,4-D in combination reduced the inefficacy of glyphosate on *Imperata, Paspalum,* and *Arundinella* but increased its effectiveness in control of *Panicum*. Paraquat + diuron followed twice by paraquat controlled these perennial grasses 34 to 45% except *Panicum* which accounted for 68% control at the end of 12 weeks.

**Table 3.18.** *Control of mixed perennial grasses by glyphosate and other herbicides used in tea.*

| Herbicide & rate (kg/ha) | Weeks after application | Control of weeds* (%) Im | Pn | Pp | Sc | Ar |
|---|---|---|---|---|---|---|
| Glyphosate 0.4 (once) | 4 | 35 | 30 | 26 | 15 | 23 |
| | 8 | 65 | 100 | 76 | 40 | 58 |
| | 12 | 70 | 70 | 70 | 33 | 63 |
| Glyphosate 0.8 (once) | 4 | 60 | 70 | 36 | 23 | 26 |
| | 8 | 85 | 100 | 85 | 51 | 70 |
| | 12 | 80 | 90 | 85 | 70 | 73 |
| Glyphosate 2.0 (once) | 4 | 83 | 100 | 63 | 60 | 81 |
| | 8 | 95 | 100 | 100 | 81 | 91 |
| | 12 | 94 | 98 | 88 | 90 | 90 |
| Glyphosate 0.4 + diuron 0.5 (once) | 4 | 33 | 50 | 32 | 20 | 31 |
| | 8 | 60 | 98 | 30 | 35 | 56 |
| | 12 | 56 | 98 | 30 | 48 | 43 |
| Glyphosate 0.4 + 2,4-D 0.8 (once) | 4 | 25 | 45 | 30 | 35 | 23 |
| | 8 | 50 | 90 | 26 | 31 | 46 |
| | 12 | 36 | 95 | 27 | 37 | 43 |
| Paraquat 0.4 + diuron 0.5 (once); Paraquat 0.4 (twice) | 4 | 36 | 60 | 16 | 50 | 56 |
| | 8 | 40 | 80 | 20 | 13 | 41 |
| | 12 | 45 | 80 | 34 | 40 | 45 |
| Paraquat 0.4 + 2, 4-D 0.5 (once); paraquat 0.4 (twice) | 4 | 30 | 45 | 16 | 43 | 50 |
| | 8 | 40 | 40 | 23 | 46 | 50 |
| | 12 | 35 | 43 | 31 | 48 | 43 |

*The abbreviations refer to Imperata cylindrica (Im), *Panicum hamidorum* (Pn), *Paspalum sp.* (Pp), *Saccharum spontaneum* (Sc) and *Arundinello bengalensis* (Ar)

## CONTROL OF INDIVIDUAL WEEDS

**1. Paspalum conjugatum**

Two pot trials conducted on actively growing *Paspalum conjugatum* indicated that paraquat (0.15 kg/ha) + MSMA (1.0 kg/ha) combination was more effective than paraquat (0.15 and 0.30 kg/ha) alone. Similarly, paraquat (0.30 kg/ha) + oxyfluorfen (0.75 kg/ha) was better than either of them applied alone; its effect at this high dose combination was 58% as against 48% observed at the low dose (paraquat 0.15 kg/ha + oxyfluorfen 0.38 kg/ha) combination.

**2. Cynodon dactylon**

The paraquat-MSMA and paraquat-oxyfluorfen trial, conducted on *Paspalum* and reported earlier, was also conducted twice on *Cynodon dactylon*. The results indicated that neither MSMA nor oxyfluorfen alone had any effect on *Cynodon*. But tank mixing of either MSMA or oxyfluorfen caused only a moderate increase in the activity of paraquat.

In three separate pot experiments the effect of paraquat and paraquat + MSMA treatments on *Cynodon* were compared with that of glyphosate. At 0.8 kg/ha, glyphosate eliminated this persistent perennial grass completely (100%) in three weeks after application (Table 3.19). The control of *Cynodon* by paraquat + MSMA treatments was only 38 to 45%.

**Table 3.19.** *Control (%) of Cynodon dactylon by glyphosate, paraquat, MSMA and paraquat + MSMA.*

| Herbicide | Rate (kg/ha) | Weeks after application | | |
|---|---|---|---|---|
| Glyphosate | 0.4 | 21 | 40 | 62 |
| Glyphosate | 0.8 | 41 | 100 | 100 |
| Paraquat | 0.20 | | 65 | 40 |
| Paraquat | 0.40 | 70 | 53 | 23 |
| MSMA | 1.0 | 15 | 12 | 5 |
| Paraquat + MSMA | 0.2+0.5 | 70 | 49 | 40 |
| Paraquat + MSMA | 0.2+1.0 | 70 | 50 | 38 |
| Paraquat + MSMA | 0.4+0.5 | 74 | 69 | 42 |
| Paraquat + MSMA | 0.4+1.0 | 76 | 63 | 45 |

**3. Control of Polygonum chinense**

A pot experiment was conducted to study the effect of glyphosate-2,4-D (amine) combination on *Polygonum chinense*, the persistent perennial broadleaf weed in tea, as against glyphosate alone.

The combination of glyphosate 0.8 kg/ha + 2, 4-D 0.72 kg/ha gave better control of *Polygonum* than when glyphosate was applied alone at 0.8 kg/ha (Table 3.20). But the efficacy of glyphosate alone 1.2 kg/ha was much higher than this glyphosate -2,4-D tank mixture. Tank mixing of 2,4-D amine with 0.4 and 0.8 kg/ha rates of glyphosate enhanced the effect of the latter.

**Table 3.20.** *Control (%) of Polygonum chinense by glyphosate alone and in combination with 2,4-D amine*

| Herbicide | Rate (kg/ha) | Weeks after application | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 10 |
| Glyphosate | 0.4 | 20 | 33 | 40 | 31 | 30 | 20 |
| Glyphosate | 0.8 | 25 | 50 | 65 | 60 | 55 | 45 |
| Glyphosate | 1.2 | 25 | 55 | 75 | 78 | 80 | 80 |
| 2,4-D amine | 0.72 | 33 | 31 | 25 | 20 | 10 | 0 |
| Glyphosate + 2,4-D amine | 0.4 + 0.72 | 53 | 60 | 61 | 54 | 36 | 30 |
| Glyphosate + 2,4-D amine | 0.8 + 0.72 | 55 | 70 | 71 | 70 | 73 | 60 |

### 4. Control of Ferns

In a field trial, the normal and solubilized formulations of glyphosate and asulam were tested at various rates for control of ferns.

Glyphosate was extremely effective with 93 and 100% control of ferns (5 weeks after application) at 0.4 and 0.8 kg/ha respectively. At these rates, there was no difference in the effect of glyphosate and solubilized glyphosate. Asulam controlled this weed only partially, and at 0.8 and 1.6 kg/ha solubilized asulam appeared to be slightly more effective.

Dow 290, a new postemergence herbicide controlled this weed 45 to 48%.

## HERBICIDE ACTIVITY AND ITS ENHANCEMENT

### 1. Tank mixing of other herbicides with glyphosate

In a field experiment on a pure stand of actively growing *Imperata cylindrica*, the effect of glyphosate when tank mixed with dalapon, diuron, paraquat, MSMA or 2,4-D was studied. Glyphosate was applied at 0.4 and 0.8 kg/ha. Other herbicides were applied at the rates recommended by Tocklai and the response shown by these single treatments was compared with that shown by the combination treatments of glyphosate (0.4 kg/ha) + other herbicides at half of the normal rate.

At 0.8 kg/ha, glyphosate gave better control of *Imperata* than at 0.4 kg/ha. The effect of other herbicides when applied alone varied from partial to poor. When tank mixed none of these herbicides showed beneficial effect on the activity of glyphosate (0.4 kg/ha). In a combination, the effect of glyphosate was very much subdued.

### 2. Fertilizer additives on herbicide activity

A pot trial was conducted on *Imperata cylindrica* to study the effect of diammonium phosphate (DAP) and single superphosphate (SSP) on the activity of glyphosate, dalapon and diuron. These fertilizers were added at 1% concentration to herbicide solution. The results indicated that neither of them had any effect on the activity of dalapon and diuron. They, however, enhanced the efficacy of glyphosate (at 0.4 kg/ha) on *Imperata* substantially. Of the two, addition of DAP resulted in greater enhancement of glyphosate activity.

In another pot trial, DAP and two nitrogen fertilizers, sulphate of ammonia (SOA) and urea were added at 0.5% and 1.0% to glyphosate (0.4 kg/ha) solution. It was indicated that of the three fertilizers, SOA at 0.5% concentration enhanced glyphosate activity markedly. The glyphosate 0.4 kg/ha + SOA 0.5% treatment was as good as glyphosate 0.8 kg/ha. Urea had no effect on glyphosate activity and DAP was effective only at 1%.

A field observation trial on a pure stand of *Imperata* further showed that SOA (at 0.5%) hastens glyphosate effect at 0.4% kg/ha and the final efficacy of the combination was much better than when glyphosate was applied alone.

### 3. Solubilization of glyphosate

Solubilized formulation of glyphosate, prepared in the laboratory by mixing the commercial glyphosate (Roundup) formulation with an emulsifier, a surfactant and a cosolvent has been tested in various pot and field experiments to study its efficacy on the control of *Imperata cylindrica*.

In the first experiment conducted in pots, soluble glyphosate was applied postemergence on the foliage of *Imperata*, 0.1, 0.2 and 0.4 kg/ha and normal glyphosate at 0.2 and 0.4 kg/ha. At 0.4 kg/ha, solubilized glyphosate gave much better control (82%) of *Imperata* (8 weeks after application) than did glyphosate (60%).

In a field trial conducted on a pure stand of actively growing *Imperata*, the efficacy of solubilized glypshosate and normal glyphosate at various rates was compared. The results (Table 3.21) showed that at 0.4 kg/ha, the effect of solubilized glyphosate on *Imperata* was much faster and quicker (41% control one week after application) than that observed in case of glyphosate (26%). The extent of *Imperata* control observed in case of glyphosate at 0.8 kg/ha (83%) was obtained at 0.4 kg/ha itself in case of solubilized glyphosate (81%).

**Table 3.21.** *Control (%) of field infestation of Imperata cylindrica by different rates of solubilized glyphosate and normal glyphosate*

| Herbicide | Rate (kg a.i./ha) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 1 | 3 | 5 | 8 |
| Glyphosate | 0.2 | 8 | 28 | 37 | 30 |
| Glyphosate | 0.4 | 26 | 48 | 53 | 50 |
| Glyphosate | 0.8 | 33 | 62 | 80 | 83 |
| Solubilized glyphosate | 0.1 | 8 | 17 | 10 | 5 |
| Solubilized glyphosate | 0.2 | 21 | 43 | 45 | 52 |
| Solubilized glyphosate | 0.4 | 41 | 67 | 82 | 81 |
| Solubilized glyphosate | 0.8 | 45 | 75 | 90 | 93 |

Another field trial on *Imperata* conducted later in the same location in Borbhetta to compare the effect of solubilized glyphosate at 0.4% kg/ha with that of glyphosate at different rates (0.4, 0.8, 1.2, 1.6 and 2.0

kg/ha), further confirmed the earlier results. The final control of *Imperata* at 0.4 kg/ha solubilized glyphosate was comparable to that obtained at 0.8 and 1.2 kg/ha glyphosate.

### 4. Effect of paraquat at higher rates

Two pot experiments were conducted on a mixed stand of *Paspalum conjugatum* and *Axonopus compressus*, the two perennial grasses commonly found in tea, to determine the efficacy of supra optimal rates of paraquat.

The results indicated that there was greater residual control of *Paspalum* and *Axonopus* at 1.0 and 1.25 kg/ha (i.e. 1:125 and 1:100 dilutions) of paraquat (Table 3.22). Diuron (0.5 kg/ha) alone had very little effect but when it was tank mixed with paraquat (0.4 kg/ha), there was 90% control of these grasses four weeks after application. This suggests that in a combination, paraquat and diuron are acting synergistically.

**Table 3.22.** *Effect of different rates of paraquat and paraquat-diuron combination on the control of Paspalum conjugatum* and *Axonopus compressus*

| Paraquat rate* (kg/ha) | Diuron rate (kg/ha) | Weed control (%) Time after application 2 days | 1 week | 4 weeks |
|---|---|---|---|---|
| 0.25 | — | 65 | 50 | 18 |
| 0.40 | — | 72 | 57 | 21 |
| 0.50 | — | 78 | 65 | 41 |
| 0.75 | — | 81 | 72 | 49 |
| 1.00 | — | 88 | 81 | 72 |
| 1.25 | — | 90 | 87 | 82 |
| — | 0.5 | 5 | 16 | 20 |
| 0.40 | 0.5 | 53 | 87 | 90 |

*The rates 0.25, 0.40, 0.50, 0.75, 1.00 and 1.25 kg/ha correspond to 1:500, 1:300, 1:250, 1:170, 1:125 and 1:100 dilutions respectively.

### 5. Paraquat activity on weeds exposed to darkness following spraying

Paraquat (0.25 kg/ha)—sprayed plants of *Paspalum conjugatum* (in pots) were kept in the dark for 1, 2, 4, 6 and 24 hr before exposing them to sun light permanently.

Scorching of *Paspalum* foliage due to the contact action of paraquat was evident within 30 min of exposure to sunlight. But this effect was not observed as long as the paraquat-treated plants were in the dark. The paraquat effect was delayed when the treated plants were kept in the dark and this delaying effect increased with increase in the dark period. There was, however, no difference in its final efficacy on *Paspalum*.

### 6. Effect of storage on dalapon activity

It is thought that during storage dalapon loses its herbicide activity. To check this, a study was taken up by initiallly storing dalapon in room temparature at 25-30°C, incubator at 40°C, and refrigerator at 5-9°C. One set of dalapon was tightly sealed in a bottle and the other left open in another bottle. Herbicide samples were taken out one month and four months after storing t test them for their efficacy in the field on a pure stand c actively growing *Imperata cylindrica*.

The results showed that there was no difference i the efficacy of various dalapon samples stored for on month. The effect was, however, reduced when it wa stored for four months in an open condition at 40°C an room temperature.

## HERBICIDE APPLICATION

### 1. Low volume application of glyphosate

Two field experiments were conducted on a pur stand of *Imperata cylindrica* to compare the efficacy of gly phosate (at 0.4 and 0.8 kg/ha) applied with Herbi, th ultra low volume (ULV) sprayer, and the conventiona hand operated bakpak sprayer. Herbi has blue, yellov and red nozzles discharging spray solution of 5.2, 10.1 and 19.2 l/hr. These nozzles were tested by spraying each plot ($3m^2$) for 10 sec discharging 15 ml, 28 ml and 5( ml for a final volume of 50, 93, and 180 l/ha with blue yellow and red nozzles respectively. The WFN 40 flood jet nozzle was used in case of the hand operated bakpak sprayer.

There was no appreciable difference in the control oi *Imperata* when glyphosate (0.4 kg/ha) was applied with WFN 40 and the three Herbi nozzles. But when glyphosate was applied at 0.8 kg/ha using the very low volume blue nozzle; its efficacy on *Imperata* control was markedly reduced. There was little difference in effect when glyphosate was applied at this rate with WFN 40 nozzle or yellow and red nozzles of Herbi. Further work in this area is in progress.

### 2. Width of Herbicide spray swath

A trial was conducted on this aspect indicated that spraying from any height above ground level, WFN 62 nozzle (fitted to the hand operated bakpak sprayer) covered a much wider swath (except when delivered at 22 cm height) than the widest row spacing (150 cm) used in tea (Table 3.23). It can, therefore, be expected that certain amount of herbicide solution will reach a part of the bush causing injury. When WFN 40 and 24 nozzles are used, the possibility of such an injury is minimal particularly if spray is delivered from a height of 22 cm to 30 cm from ground level.

**Table 3.23.** *Width of herbicide spray swath by different floodjet nozzles of hand operated bakpak sprayer*

| Nozzle | Width of spray swath (cm) at spray delivery height (cm) 20 | 30 | 45 | 60 |
|---|---|---|---|---|
| WFN 24 | 75 | 90 | 105 | 140 |
| WFN 40 | 85 | 108 | 140 | 160 |
| WFN 62 | 120 | 163 | 193 | 218 |

### 3. Rate of spray delivery

A trial conducted to determine the discharge rate of three floodjet nozzles, WFN 24, 40 and 62, used with the hand-operated bakpak sprayer, showed that at a delivery pressure of 10 psi (700 g/cm²) WFN 62 nozzle discharge spray solution at 70 to 75 l/hr as compared to 30 to 35 l/hr by WFN 40 and 12 to 15 l/hr by WFN 24. It was also revealed that in case of postemergence herbicides, substantial amount of spray solution discharged from WFN 62 nozzle found its way to the soil. Since postemergences herbicides used in tea have very little effect when applied to soil, spraying with WFN 62 nozzle becomes less efficient and economical.

### Check Testing

The following seven herbicide products have been check tested during the year and certified for use in tea.

| Trade name | Herbicide formulation | Company |
|---|---|---|
| 1. Herbucsone | Paraquat dichloride 24% WSC | Ankar Industries Pvt. Ltd. |
| 2. Paraquat dichloride 24 W/S | Paraquat dichloride | B.D. Khaitan & Co. |
| 3. Herboclin | 2,4-D sodium salt | Ankar Industries Pvt. Ltd. |
| 4. Knockweed | 2,4-D sodium salt | Mascot Chemical Works |
| 5. 2,4 D S/S | 2,4-D sodium salt | Aromate |
| 6. 2,4-D sodium salt | 2,4-D sodium salt | B.D. Khaitan & Co. |
| 7. Diuron 80% W.P. | Diuron | B.D. Khaitan & Co. |

Four other herbicide products (diuron of Atul Products, and 2,4-D 80%, dalapon 85% WSP, and simazine 50% WDP of Devidayal & Co.) were check tested during the year and certificates will be given in 1979-80. Paraquat 24% (dimethyl sulphate) of Krishi Rasayan (Bihar), check tested earlier, received certificate this year.

### Quality testing of herbicides from estates

Fourteen samples of trade formulations of herbicides, paraquat, dalapon, simazine and diuron, received from 13 estates were tested for quality. Of these, one paraquat sample was found substandard. All the others were normal.

It was interesting to note that 10 of these 14 samples were of Gramoxone formulation and these herbicides were applied mostly at rates much lower than the optimum recommended by Tocklai and finding them less effective, the estates sent them for quality testing.

### Glossary of the herbicides mentioned in the Report

The rates of all herbicides mentioned in this Report are expressed as kg active ingredient per hectare, abbreviated as kg/ha. These herbicides are referred by their common names.

The common names of herbicides used in research of 1978-79 and names of their trade products along with percentages of active ingredient are given in Table 3.24.

**Table 3.24.** *List of herbicides used in weed research in 1978-79.*

| Common name | Formulation | Trade product used in expts. | Active ingredient (%) |
|---|---|---|---|
| 1. 2,4-D sodium salt | WSP | Fernoxone | 80 |
| 2. 2,4-D dimethyl amine | WSC | Weedar 96 | 72 |
| 3. Alachlor | EC | Lasso | 50 |
| 4. Alachlor | GR | Lasso | 5 |
| 5. Asulam | EC | Asulox 40 | 40 |
| 6. Butachlor | EC | Machete | 50 |
| 7. Butachlor | GR | Machete | 50 |
| 8. Dalapon | WSP | Dowpon | 85 |
| 9. Diuron | WP | Karmex | 80 |
| 10. Dow 290 | EC | | 30 |
| 11. Glyphosate | WSC | Roundup | 41 |
| 12. MSMA | EC | Ansar 529 | 35 |
| 13. Nitrofen | GR | TOK Granules | 2 |
| 14. Oxadiazon | EC | Ronstar | 25 |
| 15. Oxyfluorfen (RH-2915) | EC | Goal | 25 |
| 16. Paraquat (dichloride salt) | WSC | Gramoxone | 24 |
| 17. Simazine | WP | Tafazine | 50 |
| 18. Solubilized glyphosate | EC | — | 4.1 |
| 19. Solubilized asulam | EC | — | 4 |

*WSP refers to water soluble powder, WSC water soluble concentrate, EC emulsifiable concentrate, GR granules, and WP wettable powder.

## Highlights

*Maximum uptake of soil phosphate by test crop takes place from the aluminium phosphate fraction under acid soil conditions. An explanation for the delayed response of phosphate in long-term field trials may lie in the fixation - release characteristics of long-term manured and freshly manured soils. The value of residual phosphate (potential P) to sustain immediately available phosphate (pool P) under continuous cropping has been emphasised. A dimensionless P supply parameter, which combines potential P, pool P and P buffering capacity of soils, has been found to be useful for defining the phosphate supplying capacity of acid tea soils and consequently P uptake by the test crop under continuous cropping.*

*Foliar method of application of trace elements like Zn, Mn and B resulted in much higher uptake of these elements as compared to soil application method at equivalent doses. Higher efficiency of uptake of chelated Mn as compared to other forms of Mn in soil application method was observed. B toxicity was observed at highest level of foliar application, when the crtical B level of leaves was between 110-120 ppm, Chinary clone, ($TV_7$) showed higher uptake of Zn than the Assam clone ($TV_{13}$), suggesting possibility of obtaining higher order of response from Zn with Chinery plants than the Assam type in Zn deficient areas.*

*Aluminium sulphate was found to be quick acting for correction of soil acidity status and its action is independent of the grain sizes as well as the textural properties of soils.*

*Attempts have been accelerated to establish the relationship between various dominant variables (soil and hydrological), with the ultimate aim to design drainage system suitable for different regions of North East India.*

## STUDIES ON PHOSPHATE

### (a) Changes in phosphate fractions due to exhaustive cropping

The changes in different phosphate fractions due to exhaustive cropping with *Pennisetum pedicellatum* for twenty months were determined and these results are given in Table 4.01.

Results show that in the case of Group A, with the exception of Eastern Dooars soil, the native aluminium phosphate fraction was remarkably depleted under exhaustive cropping. The extent of depletion was found to be 50%, 30%, 40%, 30% and 20% for Darjeeling, Western Dooars, South Bank, North Bank and Cachar soils respectively. Depletion of iron phosphate fraction was found to be 60%, 30% and 10% for Darjeeling, South Bank and North Bank soils respectively. Calcium phosphate fraction generally remained unaffected, with the exception of Eastern Dooars soils, where a 30% reduction was found due to exhaustive cropping. However, Eastern Dooars soils contained double the quantity of native calcium phosphate as compared to all other soils in the group.

**Table 4.01.** *Soil phosphate fractions before and after exhaustive cropping*

| Soil type | Details of soil | Aluminium phosphate (ppm) | | Iron phosphate (ppm) | | Calcium phosphate (ppm) | |
|---|---|---|---|---|---|---|---|
| | | Before cropping | After cropping | Before cropping | After cropping | Before cropping | After cropping |
| ***Group A** | | | | | | | |
| 1. Coarse sandy loam | Darjeeling | 335 | 160 | 600 | 240 | 100 | 92 |
| 2. Silt loam | Eastern Dooars | 215 | 230 | 415 | 400 | 220 | 150 |
| 3. Loamy sand | Western Dooars | 220 | 160 | 385 | 380 | 105 | 100 |
| 4. Silty loam | South Bank | 295 | 180 | 650 | 460 | 150 | 140 |
| 5. Sandy loam | North Bank | 515 | 360 | 450 | 400 | 120 | 125 |
| 6. Silty clay loam | Cachar | 185 | 150 | 392 | 400 | 90 | 100 |
| ***Group B** | | | | | | | |
| 7. Sandy loam | Long-term Expt. Borbhetta 105. No Phosphate | 310 | 195 | 130 | 180 | 60 | 85 |
| | 45 kg/ha $P_2O_5$ | 445 | 330 | 340 | 300 | 110 | 95 |
| | 90 „ | 490 | 305 | 400 | 260 | 192 | 105 |
| | 180 „ | 840 | 508 | 490 | 300 | 200 | 120 |

*Group A : Soil with no phosphate residues from past manuring.
Group B : Soil with phosphate residues from past manuring since 1960.

In the case of long-term phosphate manured soils under Group B, exhaustive cropping resulted in depletion of all the three phosphate fractions. Aluminium phosphate fraction depleted by about 40% in case of both unmanured and manured soils, whereas in the case of both iron and calcium phosphate similar magnitude of reduction was observed only with the higher levels of phosphate manuring at rates 90 and 180 kg $P_2O_5$/ha.

It is seen that adsorped or loosely bound phosphates in any of the three forms can serve as potential sources for supply of phosphate to the test crop under continuous cropping, although maximum release takes place from aluminium phosphate fraction under acid soil condition.

### (b) Adsorption Desorption relationship of soil phosphate

Adsorpted or potentially available phosphate is the amount that could be withdrawn from the soil solid surface into the soil solution phase constituting the immediately available phosphate during the entire period of

growth of the plant. Rate of replenishment of pool phosphate from the potential phosphate, however, depends upon phosphate buffering capacity of soils which is governed by the physico-chemical properties and the amount of phosphate that have been accumulated as a result of past manuring. Thus to gain an insight into phosphate availability problem, it is necessary to know the adsorption-desorption characteristics of our soils, and to find out whether soils differ in releasing adsorped phosphate.

All the six soils under Group A (mentioned earlier) and two other soils from long-term manuring experiments were used for finding out maximum P adsorption values and the extent of its desorption under identical laboratory conditions. Aliquot portions of each soil were treated with known quantity of phosphate (500 ppm P or 1,150 kg $P_2O_5$/ha) and shaken with 0.01(M) $CaCl_2$ (soil:solution rates as 1:20) for different periods upto 24 hrs. at two hourly intervals. The amount of phosphate adsorped at different intervals was determined and time required to attain maximum adsorption was found out. The soils with maximum adsorped phosphate were again used for the purpose of estimating cumulative desorped phosphate by shaking with 0.01(M) $CaCl_2$ over equal time periods as was required for attaining maximum adsorption. Results of adsorption-desorption kinetic studies are given in Table 4.02

**Table 4.02.** *Maximum phosphate adsorption capacity and cumulative desorption of phosphate of regional and long-term manured soils*

| Soil type | Region | Time (hours) to attain maximum adsorption | Maximum adsorped phosphate (ppm) | Percentage adsorped | Cumulative desorped phosphate (ppm) | Percentage desorped |
|---|---|---|---|---|---|---|
| ***Group A** | | | | | | |
| 1. Coarse Sandy loam | Darjeeling | 13 | 346 | 69 | 20 | 6 |
| 2. Silty loam | Eastern Dooars | 20 | 464 | 93 | 39 | 8 |
| 3. Loamy sand | Western Dooars | 16 | 394 | 79 | 28 | 7 |
| 4. Silty loam | South Bank | 19 | 462 | 92 | 31 | 7 |
| 5. Sandy loam | North Bank | 23 | 434 | 87 | 29 | 7 |
| 6. Silty clay loam | Cachar | 16 | 451 | 90 | 39 | 9 |
| ***Group B** | | | | | | |
| 7. Sandy loam | Long-term Expt. Borbhetta 43 | 24 | 189 | 38 | 60 | 32 |
| 8. Sandy loam | Long-term Expt. Borbhetta 105 | 14 | 174 | 35 | 30 | 17 |

Group A soils with no phosphate residues from past manuring.
„ B soils with phosphate residues; in expt. 43 from 1930, 112 kg $P_2O_5$/ha and in expt. 105 from 1960, 90kg $P_2O_5$ /ha.

It is seen that time required for maximum adsorption of added phosphate by soils varied between 13 to 24 hours, and maximum quantities of phosphate adsorped varied within a narrow range between 346 to 464 ppm in the case of soils under group A (i.e. without past phosphate manuring history). Amount of added phosphate adsorped by regional soils (Group A) varied between roughly 70 to 90 per cent. Soils with fine texture (2, 4 and 6) showed comparatively higher phosphate adsorption capacity than the coarse textured soils (1 and 3), which means that potential phosphate will build up faster in former group of soils compared to the latter ones at the same level of manuring. As percentage desorption of the potential (adsorped) phosphate varied little (6-9 per cent) between the regional soils (see column 7), it is expected that the potential phosphate (residual) of fine textured soils will be able to replenish the pool phosphate (immediately available) for a longer period to meet the plants requirement.

In soils under group B (i.e. with past phosphate manuring history), maximum adsorption of freshly added phosphate was found to be only 180 ppm approximately which works out to be 36 per cent of the added phosphate. The lower adsorption capacity of these soils is due to accumulation of phosphate residues from past manuring or, in other words, lower phosphate buffering capacity of the long-term manured soils. Quantities phosphate desorped, on the contrary, was found to be very much higher in these soils as compared to the group A soils without P residues from past manuring. Percentage desorped phosphate was double in case of B.105 soil and about four times in case of B.43 soil compared to Group A soils. This shows that the rate of release of freshly added phosphate from potential phosphate source to pool phosphate is much faster in long-term manured soils than unmanured soils in the past. The practical implication could be that by judicious and continuous manuring phosphate buffering capacity of tea soils can be altered and, as a result, potential phosphate (adsorped) can be made available at a faster rate for replenishing the pool from where instantaneous uptake by plant takes place. An explanation for delayed response of phosphate in long-term field trials may lie on the adsorption-desorption characteristics of tea soils with high adsorption capacity.

### (c) Supply parameter of phosphate in soils and its relation to phosphate uptake by test crop

In this study all the eight soils as mentioned earlier (six regional and two long-term manured ones) were used. These soils received phosphate dressings at 0, 60, 120 and 180 kg $P_2O_5$/ha respectively and were exhaustively cropped with *Pennisetum pedicellatum* in pots for a period of 21 months. At the end of the cropping period soils were taken out of the respective pots and utilised for working quantity (q) —intensity (c) relations by adding 400, 800, 1200 and 1600 ppm P and shaking for

10 hrs under laboratory conditions. The adsorped phosphate in soils (q) and the soil solution phosphate concentration (c) were estimated and their relations worked out.

The q vs c relations of different tea soils were found to obey the well-known Langmuir-type adsorption equation :

$q : K_1C/K_2 + C$, where q = quantity of P adsorped per g of soil, c = intensity or amount of P remaining in soil solution, $K_1$ and $K_2$ are constants. A general q vs c relation of tea soils is shown in Fig. 1, as there was not much difference between the difierent regional soils in their q vs c relationships.

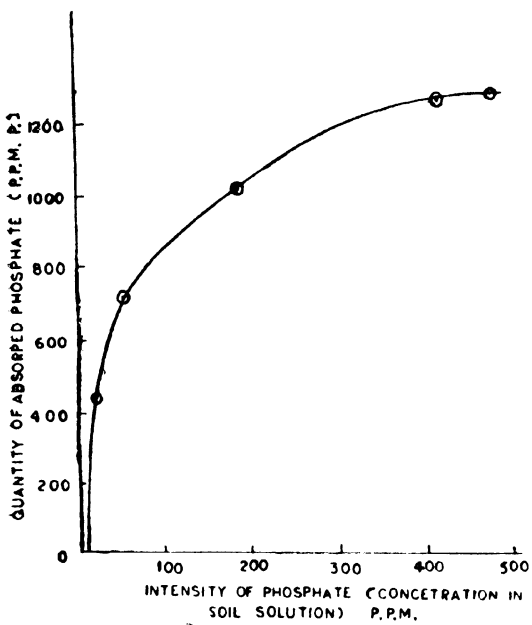



**Fig 4.01. Qnantity intensity relationships of average of tea soils.**

The q vs c relations of the two soils from long-term manuring experiments and unmanured soil shown in Fig 4.02.

From Fig. 2 it is seen that the rate of change of Q adsorped phosphorus for an unitchange of C (soil solution phosphorus) or the slopes of the curves decrease in the order B 43 > B 105 > unmanured soils.

In practice it means that with the withdrawal of soil solution or pool phosphate by plants at any one concentration (c) level, the rate of release of adsorped or potential phosphate to replenish and maintain the same concentration level will be much higher in case of long-term manured soils than unmanured ones. It is thus emphasised that both pool (c) and potentia (q) phosphates

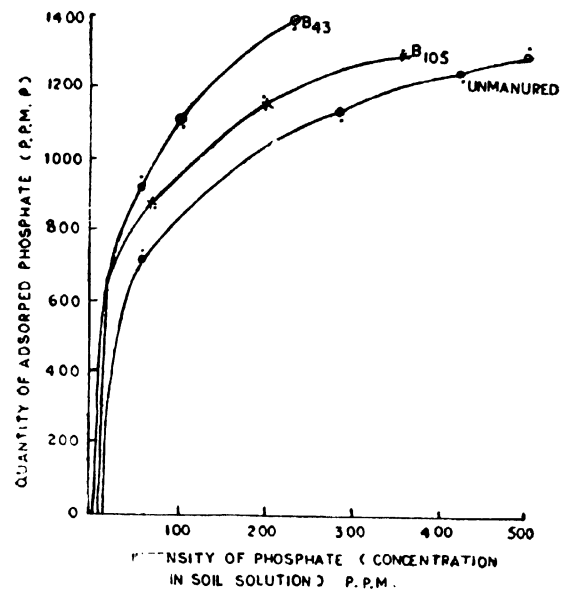



**Fig 4.02. Quantity intensity relationship of long-term manured and unmanured soils.**

should be taken into consideration while measuring soi phosphate availability to plants.

Further, a dimensionless soil supply parameter of phos phate (SP) was calculated from the q vs C relationshi of each soil included in this study using the equatio : $SP = \sqrt{AC} / \sqrt{K_1 K_2}$. This parameter combines th effects of three factors namely, the quantity (q), inten sity (C) and buffering capacity of soil phosphate ir determining the supply of phosphate from soil to plant The objectives were : (a) to test whether supply para meter bears a relationship with cumulative desorption o potential phosphate or adsorped phosphate (q) as deter mined in the laboratory, and (b) to relate the total I removed by the test crop *Pennisetum pedicellatum* to th calculated values of supply parameter of P and cumu lative desorption of P in different soils.

The relations between the supply parameter (SP) anc P concentration in soil solution (c) for the different soil at different levels of added phosphate are shown ii table 4·03.

It is seen from table 3 that both C (soil solution P con centration) and SP values increase with the increasing levels of addition of phosphates to all the soils. How ever, different trends of increase were exhibited by the unmanured and long-termed manured soils as shown ir Fig 4.03.

Both soil solution P concentration (C) and supply para meter (SP) did not differ much between unmanured anc long term manured soils upto 1200 ppm level, beyonc

**Table 4.03** *Relation between supply parameter (SP) and soil solution phosphate concentration at different levels of added phosphate*

| Soil type | Region | 400 ppm | | 800 ppm | | 1200 ppm | | 1600 ppm | |
|---|---|---|---|---|---|---|---|---|---|
| | | C | SP | C | SP | C | SP | C | SP |
| ***Group A** | | | | | | | | | |
| 1. Coarse Sandy loam | Darjeeling | 21.00 | 10.11 | 56.80 | 16.64 | 187.80 | 30.25 | 404.20 | 44.37 |
| 2. Silty loam | Eastern Dooars | 27.20 | 12.45 | 42.60 | 15.58 | 171.60 | 31.26 | 520.00 | 54.42 |
| 3. Loamy sand | Western Dooars | 17.00 | 9.60 | 77.60 | 20.50 | 198.60 | 32.80 | 404.20 | 46.80 |
| 4. Silty loam | South Bank | 24.00 | 7.03 | 76.40 | 16.04 | 195.20 | 19.97 | 336.20 | 26.21 |
| 5. Sandy loam | North Bank | 23.40 | 10.09 | 62.00 | 16.43 | 187.80 | 28.61 | 327.40 | 37.77 |
| 6. Silty clay loam | Cachar | 17.00 | 7.78 | 109.00 | 19.71 | 179.00 | 25.25 | 421.00 | 38.73 |
| ***Group B** | | | | | | | | | |
| 7. Sandy loam | Long-term Expt. Borbhetta 43 | 17.00 | 9.19 | 67.80 | 18.36 | 155.80 | 27.80 | 125.00 | 24.92 |
| 8. ,, | Long-term Expt. Borbhetta 105 | 12.60 | 9.75 | 74.20 | 23.67 | 198.60 | 38.72 | 240.20 | 42.59 |

*Group A soils with no phosphate residues from past manuring.
,, B soils with residues, expt. 43 from 1930, 112 kg $P_2O_5$/ha and expt. 105 from 1960, 90 kg $P_2O_5$/ha.

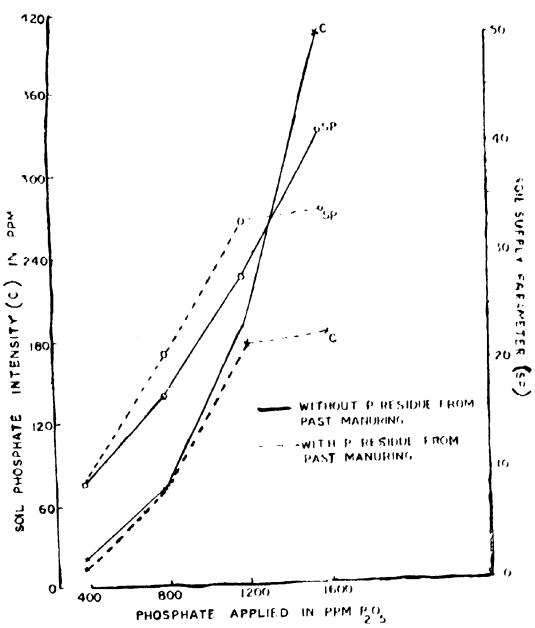



**Fig 4.03 Changes in soils solution P concentration (C) and P supply parameter (SP) with P manuring in long-term manured and previously unmanured soils.**

which with further addition of phosphate the unmanured series continued to rise sharply in C and SP values, whereas long-term manured ones failed to show further increase. However, from the nature of graphs for both unmanured and manured series (Fig 4.03), it can be said that the dimensionless P supply parameter of tea soils is well correlated with the pool phosphate or soil solution P concentration.

It was also necessary to find out the relationship between supply parameter (SP) and the potential phosphate or the cumulative desorped phosphate of these soils ($\Sigma$Pd), in order to ascertain how successfully the SP parameter can be used to find out the phosphate supplying capacity of the soils for replenishment of pool phosphate (C). Highly significant linear relationships with variable slopes for the different regional soils were observed as shown in Fig. 4.04.

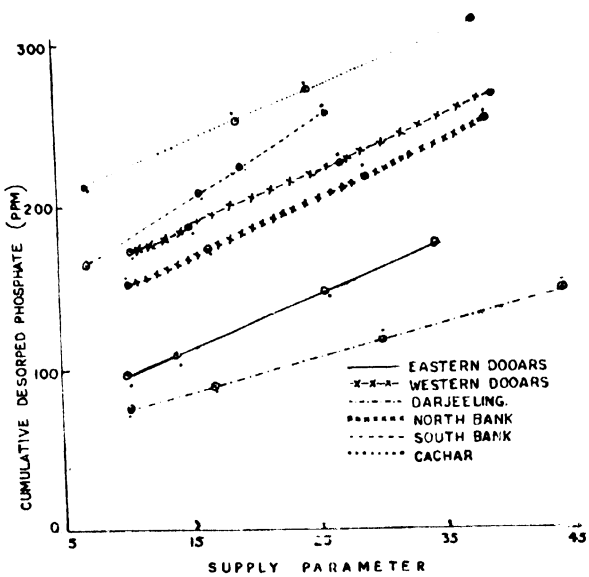



**Fig 4.04 Relationship between P supply parameter and cumulative desorped phosphate of soils.**

Further, cumulative desorped phosphate data for various levels of P added was also related with cumulative P uptake by the test crop.

To find out whether supply parameter values satisfactorily measure phosphate supply to plants, cumulative P uptake by the test crop from the different soils under various P treatments (0, 60, 120 and 180 kg $P_2O_5$/ha) was next correlated with the supply parameter values of soils under corresponding P treatments. Highly significant linear relationships were found to exist between supply parameter and total phosphate removed by *Pennisetum* from the different soils as shown in Fig 4.05.

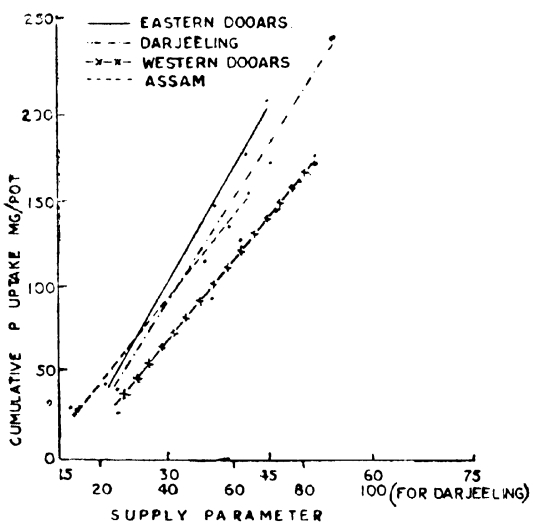



**Fig 4.05. Relationship between P Supply parameter of soils and cumulative P uptake (mg/pot) by test crop for 21 months exhaustive cropping.**

The relationships indicate that the point of maximum uptake was not approached in any of the four soils. The linear relationships, however, siggest that supply parameter value is a suitable index for measuring P uptake by plant. This conclusion is also supported by the significant linear relationship observed between supply parameter and cumulative desorped phosphate from soils mentioned earlier. Evidently, these studies suggest that either of these two measurements namely supply parameter or cumulative desorped phosphate can be successfully used to define the P supplying capacity of acid tea soils and consequently P uptake by plant.

### (d) Relative availability of different phosphatic fertilisers in acid soils

For the purpose of this experiment, four different forms of phosphate Superphosphate, Amonium phosphate, Dicalcium phosphate and Rock phosphate (Mussorie) were used. Phosphate at two levels, *viz*, 45 and 90 ppm (i.e. about 100 and 200 kg $P_2O_5$ per hectare) were mixed with aliquot portions of a sandy loam soil (pH 4.6), and these pre-treated soils were incubated for varying periods of 7, 15, 30, 45 and 60 days under laboratory conditions. During the period of incubation temperature was kept constant at 30°C and moisture was maintained all through at 50 p.c. of the total water holding capacity of the soil. After respective periods of incubation, the soils were extracted with Bray-1 extractant (amonium fluoride + hydrochloric acid) for finding out the release of added phosphate in the available form. Soil pH was measured before and after incubation in soil water extract in the ratio of 1:2.5. The results are given in table. 4.04.

The results showed that dicalcium phosphate can be used as an alternative phosphate source in place of superphosphate, since its immediate availability was found to

**Table 4.04.** *Net release of added phosphate from various P sources at different periods of incubation (data expressed as ppm $P_2O_5$).*

| Form of phosphate | Rate of $P_2O_5$ added, ppm | Period of incubation (days) and P-release after incubation for days | | | | | Average | % P. released | end pH |
|---|---|---|---|---|---|---|---|---|---|
| | | 7 | 15 | 30 | 45 | 60 | | | |
| Di-Calcium | 45 | 8.2 | 8.2 | 4.6 | 2.3 | 3.7 | 5.4 | 12.0 | 4.60 |
| phosphate | 90 | 19.7 | 15.1 | 10.5 | 27.5 | 26.6 | 19.9 | 22.1 | 4.60 |
| Superphosphate | 45 | 3.7 | 6.9 | 3.7 | 2.3 | 4.6 | 4.2 | 9.3 | 4.50 |
| | 90 | 6.0 | 4.6 | 6.9 | 11.5 | 13.7 | 8.4 | 9.4 | 4.50 |
| Ammonium | 45 | 3.7 | 3.7 | 1.8 | 0.9 | nil | 2.5 | 5.6 | 4.45 |
| Phosphate | 90 | 8.2 | 11.5 | 13.3 | 9.2 | 12.8 | 11.0 | 12.2 | 4.40 |
| Rock | 45 | 1.4 | 1.4 | nil | nil | 8.2 | 3.7 | 8.2 | 4.60 |
| phosphate | 90 | 2.3 | 2.3 | nil | 9.2 | 15.1 | 7.2 | 8.0 | 4.60 |
| | | | | | | pH of untreated soil | | : | 4.60 |

Dicalcium phosphate (Total available phosphate ($P_2O_5$) 42.51%; Super-phosphate (Total available $P_2O_5$ 20.61%); Ammonium phosphate (Total available $P_2O_5$ 21.33%; Mussoric rock phosphate (Total $P_2O_5$ 24.05%).

be relatively higher and the release of avilable P fraction also remained fairly sustained as compared to the standard superphosphate. Immediate availability of rock phosphate was found to be the least, although release of avilable P fraction from this form tended to increase with high (200 kg $P_2O_5$/ha) rates of phosphate application after a prolonged period of incubation for sixty days. The release of P from mono-ammonium phosphate treated soil was all through lower compared to either superphosphate (SP) or dicalcium phosphate (DCP) at application rate of 100 kg $P_2O_5$/ha, but at 200 kg $P_2O_5$/ha the release of phosphate was found to be fairly comparable with either DCP or SP. The pH status of phosphate treated soils at the end of incubation

period remained virtually unaltered at the end of sixty days.

### (e) Effect of liming on phosphate transformation and availability in acid tea soils.

A sandy loam soil having pH 4.35 was chosen for the experiment. The soil was pre-treated with calcium hydroxide at levels 660 ($L_1$) and 1,000 kg/ha ($L_2$) as per pre-determined theoretical requirement to alter the pH by 0.5 and 1.0 units respectively, and incubated for 45 days at room temperature and at 50 p.c. moisture holding capacity. An unlimed control soil was also included.

At the end of the incubation period, when desired pH levels were attained phosphate was added as potassium hydrogen phosphate at rates 0, 60, 120 and 180 kg $P_2O_5$/ha to aliquot portions of both limed and unlimed soils and incubated as previously for periods of 7, 30 and 45 days. After respective period of incubation, soils were analysed to find out the influence of liming on the transformation and distribution of various inorganic soil phosphate fractions.

Results showed that lime had practically no effect on the water soluble phosphate fraction (i.e. the pool phosphate). Pre-treatment with lime resulted in significant increase of aluminium phosphate fraction at all levels of phosphate application, but increasing the level of lime from 660 to 1,000 kg/ha (i.e. from $L_1$ to $L_2$) did not significantly increase aluminium phosphate fraction except at the highest dose (180 kg $P_2O_5$/ha) of phosphate application as shown in Fig 4.06.

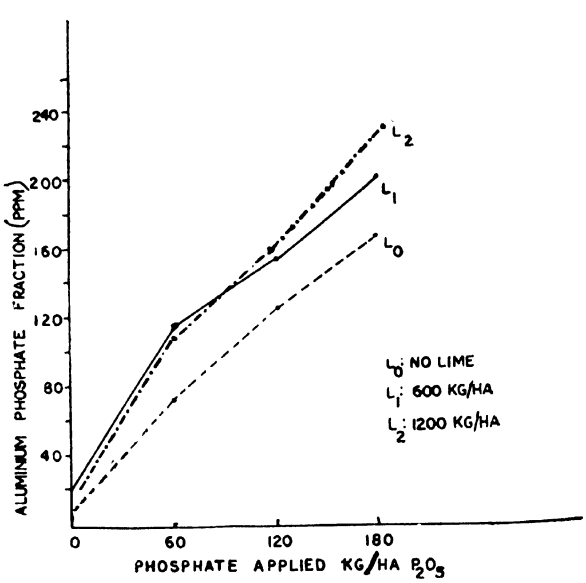



**Fig 4.06. Effect of pre-treatment with lime on the distribution of Al fraction of soils.**

Compared to unlimed soils, lime application at the rate of 660 kg/ha ($L_1$) increased aluminium phosphate fraction by 150, 62.5, 23.2 and 38.0 per cents at phosphate application rates 0, 60, 120 and 180 kg $P_2O_5$/ha respectively. A decreasing effect of liming on the iron phosphate fraction of soil had been observed as shown in Fig 4.07.

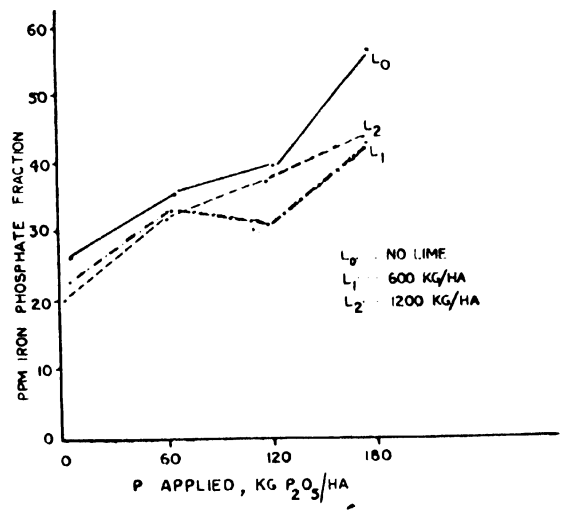



**Fig 4.07. Effect of pre-treatment with lime on the distribution of Fe-P fraction of soil.**

Calcium phosphate fraction did not change much as a result of liming, with the exception of phosphate untreated soil.

It has also been observed (earlier in this report) that aluminium phosphate fraction undergoes maximum depletion under exhaustive cropping with a test crop compared to all other inorganic P-forms, and, as such, pre-treatment of lime can be of help in utilisation of applied phosphate from P-responsive soils.

## STUDIES ON TRACE ELEMENTS

### (a) Correlation studies between available zinc and physico-chemical properties of tea soils

For this purpose 476 soils from different regions of North East India were analysed for available zinc (dithiozone-NH4 acetate extraction), pH, organic matter, finer soil fractions (silt+clay) and available phosphate (Bray-1) contents. Simple correlation studies showed that :

(i) pH of the soils (varying generally within the range 4.0-5.0) did not significantly influence zinc availability, with the exception of Cachar soils (which had a wider variation in pH content than in other regions), where a highly significant positive correlation was observed.

(ii) Organic matter did not influence zinc availability in old allumvium soils of Assam South Bank and Cachar and new allumium of North Bank, but a negative correlation was observed (significant at 5 p.c. level) for West Bengal soils which

are at least 2-3 times rich in organic matter compared to Assam soils.

(iii) Finer soil fractions, like silt and clay, showed a highly significant positive influence on zinc availability in all the regions with the exception of Darjeeling (where soils are formed *in situ*).

(iv) A highly significant negative influence of phosphate on available zinc was observed in case of Cachar and North Bank soils.

Multiple correlations between available zinc and soil factors like pH, Organic matter, finer soil fractions and phosphate were also carried out.

The correlations coefficients and relative contribution of individual soil factor towards available zinc are given in Table 4.05.

**Table 4.05.** *Correlation coefficients between available zinc and other soil factors, and relative contribution of individual soil factor*

| Region | Relative contribution (per cent towards available zinc) | | | | | Multiple correlation coefficient | Significance Level |
|---|---|---|---|---|---|---|---|
| | pH | Organic matter | Finer fraction | Available $P_2O_5$ | Total | | |
| South Bank | 0.05 | 0.01 | 16.54 | 0.21 | 16.81 | 0.4294 | *** |
| North Bank | 0.89 | 1.40 | 8.49 | 6.05 | 16.83 | 0.5321 | *** |
| Cachar | 2.89 | 0.52 | 27.75 | 11.99 | 43.15 | 0.7644 | *** |
| Dooars & Terai | 0.23 | 5.10 | 4.97 | 1.83 | 12.13 | 0.3277 | * |
| Darjeeling | 0.04 | 2.44 | 0.86 | 0.83 | 4.17 | 0 2023 | N.S. |

These data show that all the four factors together contribute significantly towards available zinc, with the exception of Darjeeling soils. Relative contribution of finer soil fraction was found to be the highest, followed by available phosphate content. Organic matter influenced in a substantial way only in case of West Bengal soils. However, the total contribution of these soil factors towards available zinc varied betwen 4 and 17 per cent only, with the exception of Cachar where the total contribution was found to be 43 per cent.

### (b) Evaluation of clones for zinc uptake efficiency

The experiment was carried out with three year old clonal plants in pots under green house conditions. Four clones *viz*, TV1 (hybrid ), TV7 (Chinary), TV 18 (Cambode) and TV13 (Assam) were included. Potted plants were supplied with zinc sulphate at rates 0, 10, 20, 30 and 40 kg/ha by soil application method and at rates 0, 5, 10, 15 and 20 kg/ha by foliar application method. The foliar application was carried out in ten sprays at fortnightly intervals using spray fluid concentrations of 0, 0.5, 1.0, 1.5 and 2.0 p.c. (W/V) respectively.

The plants were harvested after six months, dry weights recorded, and total uptake of zinc was determined for individual plants. Results are given in Table 4.06.

**Table 4.06.** *Zinc uptake by different clones with varying levels and methods of zinc sulphate application (data expressed as mg/g dry matter)*

*$M_1$ = Foliar application method and $M_2$ = Soil application method.

| Clones / ZnSO4 kg/ha | TV13 | | TV1 | | TV18 | | TV7 | |
|---|---|---|---|---|---|---|---|---|
| * $M_1$ | $M_2$ | $M_1$ | $M_2$ | $M_1$ | $M_2$ | $M_1$ | $M_2$ | $M_1$ | $M_2$ |
| 0 | 0 | 0.101 | 0.101 | 0.102 | 0.103 | 0.115 | 0.114 | 0.119 | 0.121 |
| 5 | 10 | 0.269 | 0.117 | 0.314 | 0.137 | 0.334 | 0.145 | 0.364 | 0.181 |
| 10 | 20 | 0.338 | 0.158 | 0.424 | 0.172 | 0.460 | 0.162 | 0.534 | 0.210 |
| 15 | 30 | 0.441 | 0.181 | 0.534 | 0.193 | 0.541 | 0.186 | 0.647 | 0.250 |
| 20 | 40 | 0.531 | 0.208 | 0.575 | 0.219 | 0.564 | 0.239 | 0.690 | 0.269 |
| Mean of levels | | 0.336 | 0.153 | 0.390 | 0.165 | 0.403 | 0.169 | 0.471 | 0.206 |
| Mean of methods | | $M_1$ (foliar) 0.400 | | | | $M_2$(soil) 0.173 | | | |

C.V. p.c. = 9.87; C.D. at 5% for clone = 0.012; C.D. at 5% for method = 0.008; C.D. at 5% for zinc = 0.014.

From table 4.06 it is seen that uptake of zinc varied significantly ($P<0.001$) between different clones under both the methods of application of zinc sulphate. Uptake decreased significantly in the order $TV_7 > TV_{18} = TV_1 > TV_{13}$.

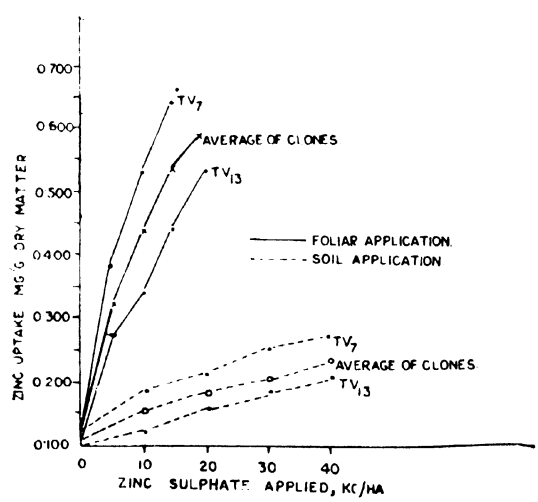



**Fig 4.08. Comparison of zinc uptake by clones with increasing levels of zinc by soil and foliar method of application.**

Fig. 4.08. shows that chinary clones ($TV_7$) have higher requirement (uptake)of zinc than the Assam clones ($TV_{13}$) and, as such, in zinc deficient areas Chinary clones are likely to show a higher order of response of applied zinc than the Assam type of clones.

Foliar method of application resulted in much higher zinc uptake than soil application method in all the clones as seen in Fig. 4.08. Even at double the doses

of application of zinc sulphate in soil as compared to foliar method, total uptake by clonal plants by former method was less than half of the amount absorbed by the plants under the latter method.

### (c) Studies on the uptake of boron and manganese

A pot experiment was carried out in glasshouse to study the uptake of foliar and soil application of manganese and boron by 18 months old clonal plants. Plants were grown in a sandy loam soil having 150 ppm total Mn, 2 ppm water-soluble Mn, 4 ppm exchangeable Mn and 10 ppm reducible Mn. Plants receiving foliar application of Mn and B were grown for six months, and those receiving soil application of Mn, B and EDTA were grown for one year. Treatments were as follows :

i) **Manganese, soil application**

Manganese sulphate ($MnSO_4.2H_2O$) kg/ha : 0, 10, 20 and 40

" " mg/pot : 0, 40, 80 and 160.

ii) **Manganese + Na-Salt of EDTA, soil application**

| Kg/ha manganese sulphate | EDTA ppm |
|---|---|
| 0 | 33.5 |
| 10 | 33.5 |
| 0 | 67 |
| 20 | 67 |
| 0 | 134 |
| 40 | 134 |

iii) **Manganese, foliar application**

Per cent (W/V) manganese sulphate

Kg/ha " : 0, 1, 2 and 4.

(in ten sprays, fortnightly intervals) : 0, 10, 20 and 40.

iv) **Boron soil application**

Boric acid ($H_3BO_3$) kg/ha : 0, 1, 2, 4, and 6.

" " mg/pot : 0, 4, 8, 16 and 24

v) **Boron, foliar application**

Per cent (W/V) boric acid

kg/ha " : 0, 0.01, 0.02, 0.04 and 0.06

(in ten sprays at fortnightly intervals) : 0, .1, .2, .4 and.6

A basal dressing of N, P and K at rates 90, 45 and 120 kg /ha respectively were given. Treatments were imposed about one month after the plants were established. After harvesting the plants were seperated into three fractions *viz*, leaf, stem, and root, dry weights recorded and analysed for Mn and B as the case may be. The effects of increasing doses of manganese application in soil, either in combination or without EDTA, on the total uptake of Mn by the plants are shown in table 4.07.

**Table 4.07.** *Effect of soil application of manganese, and manganese plus EDTA on total Mn uptake*

| Manganese added, Mn kg/ha | Sodium EDTA added, ppm | Manganese uptake mg/plant | | | |
|---|---|---|---|---|---|
| | | Leaf | Stem | Root | Total |
| PART A | | | | | |
| 0 | Nil | 12.02 | 3.23 | 2.93 | 18.18 |
| 10 | " | 14.25 | 4.10 | 3.30 | 22.65 |
| 20 | " | 16.53 | 5.15 | 3.66 | 25.34 |
| 40 | " | 19.15 | 6.13 | 4.08 | 29.36 |
| Mean | " | 15.49 | 4.65 | 3.49 | 23.63 |
| PART B | | | | | |
| 0 | 33.5 | 12.67 | 3.50 | 3.41 | 19.58 |
| 10 | 33.5 | 14.93 | 4.33 | 3.49 | 22.75 |
| 0 | 67 | 14.43 | 4.40 | 3.53 | 22.36 |
| 20 | 67 | 18.35 | 5.86 | 3.93 | 28.14 |
| 0 | 134 | 14.43 | 4.59 | 3.79 | 22.81 |
| 40 | 134 | 21.52 | 6.52 | 4.53 | 32.57 |
| | C.D. at 5% | 0.55 | 0.33 | 0.018 | |
| | " " " 1% | 0.75 | 0.45 | 0.925 | |

Manganese application alone at 10, 20 and 40 kg Mn/ha resulted in 20, 40 and 60 per cent higher Mn uptake per plant respectively compared to those not receiving manganese.

EDTA further increased Mn uptake in various plant fractions at all levels of application of Mn. The increases due to EDTA over Mn alone (compare part B with part A) were 5, 11 and 11 per cents for 10,20 and 40 kg Mn/ha application rates respectively, thereby indicating higher efficiency of uptake of chelated manganese compared to other forms of manganese. Fig 4.09 shows that

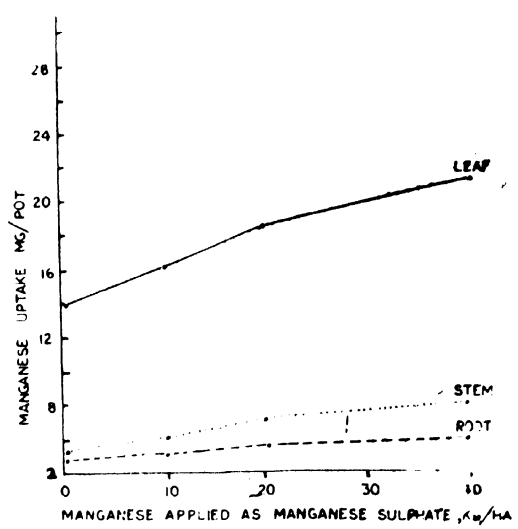



**Fig 4.09. Manganese uptake by various plant fractions with application of Mn in soil.**

Mn uptake by leaves is at least three to four folds as compared to stem or root.

Manganese uptake by different parts of tea plant under foliar application method also increased significantly and progressively with increasing levels of Mn application. However total uptake of manganese by plant with foliar application method was found to be remarkably higher compared to the soil application method as shown in Fig 4.10.

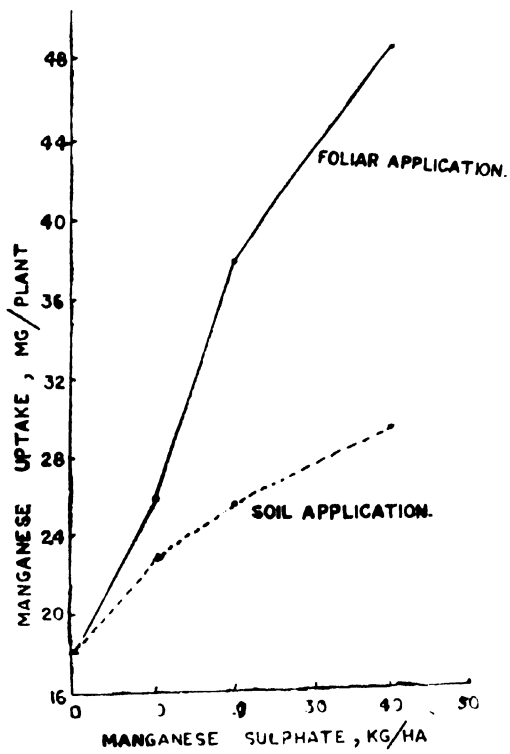



**Fig 4.10. Comparison of manganese uptake by tea from soil and foliar method of application of manganese sulphate.**

Total uptake by the whole plant under foliar application method increased by 18, 48 and 65 per cent over soil application method for rates 10, 20 and 40 kg Mn/ha respectively. Mn toxicity was not exhibited by the plants even at the highest level of manganese application (i.e. 40 kg Mn/ha) both by soil and foliar methods.

The effects of increasing doses of boron application in soil on the total uptake of boron by plants are shown in Table 4.08.

Boron uptake increased progressively in all the three plant fractions with increasing levels of application of boron in soil. Total uptake of boron per plant increased by 60, 90, 120 and 170 per cents compared to control for rates of application 1,2,4 and 6 kg B/ha respectively. It is

**Table 4.08.** *Effect of soil application of boron on total boron uptake.*

| Boron added as boric acid kg/ha | Boron uptake mg/plant | | | |
|---|---|---|---|---|
| | Leaf | Stem | Root | Total |
| 0 | 0.26 | 0.61 | 0.15 | 1.02 |
| 1 | 0.63 | 0.79 | 0.21 | 1.63 |
| 2 | 0.77 | 0.91 | 0.23 | 1.91 |
| 4 | 0.99 | 0.97 | 0.24 | 2.20 |
| 6 | 1.41 | 1.05 | 0.26 | 2.72 |
| Mean | 0.81 | 0.87 | 0.22 | — |
| C.D. at 5% | 0.021 | 0.060 | 0.060 | |
| C.D. at 1% | 0.030 | 0.091 | 0.085 | |

interesting to note that boron content of stem was either higher or about equal to that of leaf at different levels of application of boron.

Foliar application of boron also resulted in significant and progressive increase in the uptake of boron by both leaf and stem fractions with increasing application rates. However, contrary to soil application method, leaf under foliar spray contained more boron than their stem counterparts at various application rates of B as shown in Fig 4.11.

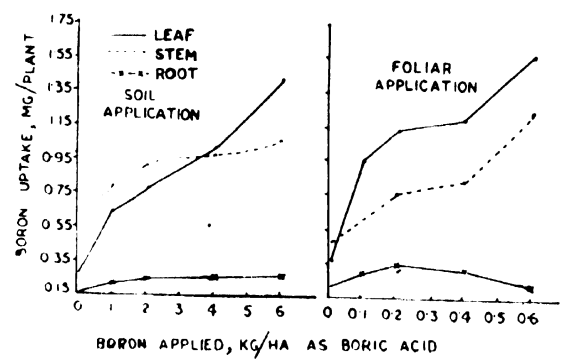



**Fig 4.11. Comparison of boron uptake by different plant fractions from soil and foliar methods of boric acid application.**

Fig 4.11 further shows that foliar applications at much lower rate (one-tenth) was as effective as higher rates of application of boric acid in soil from the point of view of boron uptake by tea plant. At 0.6 per cent concentration severe scorching was observed after the seventh spray schedule, when leaves defoliated. Boron toxicity symptoms observed were irregular brown patches of dead tissue starting from interveinal region and extending towards leaf margin and curling of leaf blades. The level of boron for inducing toxicity was found to be between 110 -120 ppm.

## EFFECT OF ALUMINIUM SULPHATE ON SOIL ACIDITY

An experiment was carried out in the laboratory to find out whether efficiency of aluminium sulphate for correction of soil acidity status is influenced by soil tex-

ture, particle size of aluminium sulphate and time of reaction between soil and the chemical. For this purpose three soils belonging to sandy loam, silty clay loam and loamy textures having pH values between 5.85 to 7.30 were treated with aluminium sulphate at the rate of 10, 20 and 40 tonnes per hectare using two particle sizes of aluminium sulphate *viz*, coarse (granulated) and fine (powdered) particles. Treated soils were kept at room temperature and at 50 p.c. of their moisture holding capacity, for a period of four months, and pH was determined at fortnightly intervals in soil suspension.

Results are shown graphically in figures 12, 13 and 14. Fig 4.12 shows the effect of aluminium sulphate on the changes of pH content of various soil types.

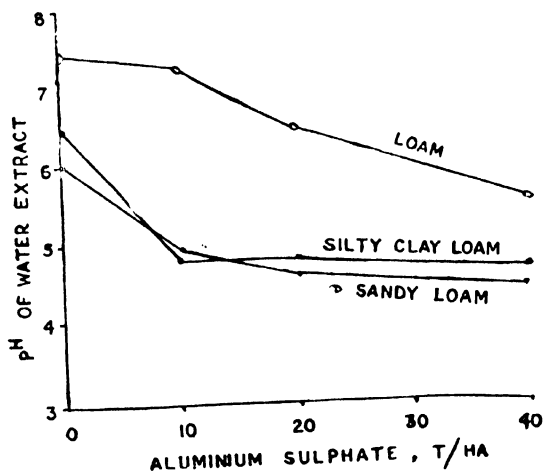



**Fig 4.12. Effect of aluminium sulphate on the changes in pH content of soil.**

It is seen from Fig 4.12 that both sandy loam and silty clay loam soils with initial pH values between 6.0- 6.5 could be corrected to pH 5.0 within a very short period of four months by application of 10 t/ha aluminium sulphate, whereas the loamy soil with an initial pH value of 7.4 could not be corrected to pH 5.0 over the same period even with 40 t/ha aluminium sulphate application. Rate of application of aluminium sulphate for increase of soil acidity thus depends mainly upon initial pH and is independant of the soil textural characteristics.

Fig 4.13 shows the effect of aluminium sulphate of different grain sizes on the pH content of soils. It is seen from Fig 4.13 that the granulated aluminium sulphate with coarser particle size is as effective as the powdered form with fine particle size for increasing acidity content of soil. The coarser form can thus be used with economic advantage, provided the chemical is well-mixed with soil particles either in the planting pits or during the time of ploughing and land preparation.

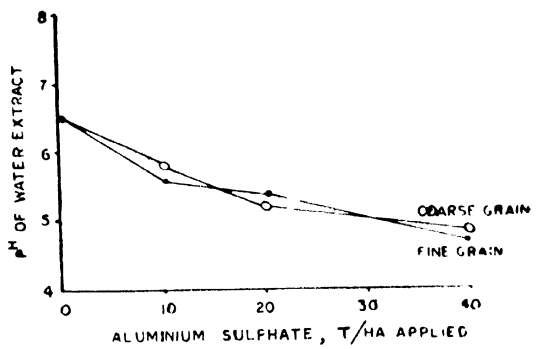



**Fig 4.13. Effect of grain size of Aluminium sulphate on the changes in soil pH content**

Fig 4.14 shows the effect of period of incubation of aluminium sulphate treated soils on the changes in pH content.

Fig 4.14 shows that the chemical was quick acting since pH values dropped sharply within the first fortnight of the application of the chemical. pH, however, increased

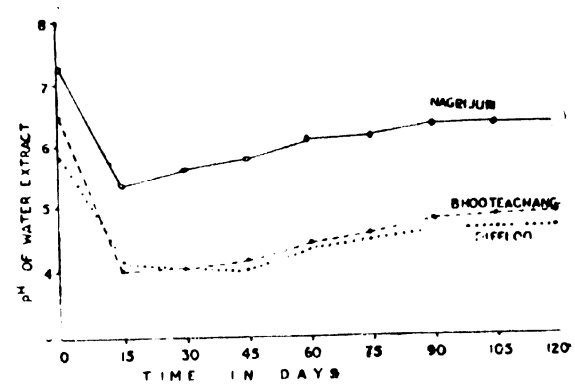



**Fig 4.14. Effect of period of incubation of Al-sulphate treated soil on pH content.**

slightly for a period of three months, at the end of which the changes in pH values were stabilised. This last observation confirms the present recommendation that for following up correction of soil acidity with aluminium sulphate in sub-acidic areas, soil samples should be reexamined three months after the application of the chemical.

## STUDIES ON GROUND WATER DRAINAGE PROBLEMS

The studies on groundwater drainage include mainly the following :

Ground water table mapping in tea soils of North-East Indian region; quantification of the variables influencing the design of drainage system; developing a functional relationship between different dominant variables; developing a suitable drainage design criteria.

To study the above objectives several experiments have been taken up.

(a) **Water Table Mapping**

The work on groundwater table investigation has been extended to several gardens. It is proposed to extend this study further.

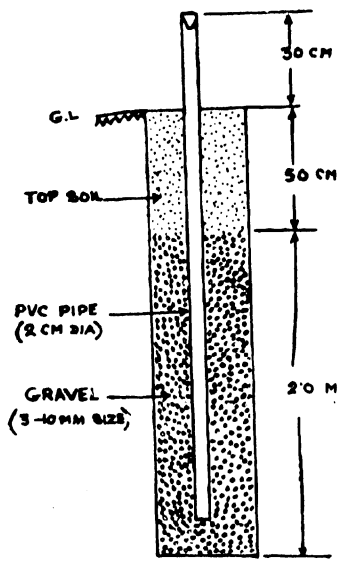



**Fig 4.15. Observation well for Water Table measurement.**

A set of observation wells as shown in Fig 4.15 was installed in 30 sites to study the groundwater table. The water level in the observation wells installed at various spacings in the fields was recorded manually with the help of a plopper. The data were then used to develop the water table profiles. This information will help in selecting a suitable type of drainage system needed for a given area and help in evaluating a suitable drainage design criteria.

(b) **Pipe Drainage Experiment**

The pipe drainage experiments have been laid out in Hunwal, Harroocharai and Mogulkata tea estates during the year 1978-79.

The results obtained from the above experiments are being compared with the results from a comparable section having conventional drainge system in the respective estates.

The soil from the experimental sites is being analysed for various soil physical properties. Some results obtained from Harroocharai T.E. (Section No. 25B) are presented in tables 4.09 and 4.10.

The results show that the soil of the experimental plot falls in the category of loamy sand type. A deser layer

**Table 4.09.** *Particle size distribution of soil in the Experimental Field (Harroocharai T.E., No. 25B)*

| Sl. No. | Depth of soil sampling, cm | Sand % | Silt % | Clay % | Textural classification |
|---|---|---|---|---|---|
| 1. | 0— 45 | 80 | 17 | 3 | Loamy Sand. |
| 2. | 45— 90 | 74 | 22 | 4 | Loamy sand. |
| 3. | 90—135 | 77 | 18 | 5 | Loamy sand. |
| 4. | 135—180 | 73 | 23 | 4 | Loamy sand. |
| 5. | 180—210 | 72 | 24 | 4 | Loamy sand. |

**Table 4.10.** *Soil physical properties in the Experimental Field (Harroocharai T.E. Section No. 25B)*
Soil texture — Loamy sand.
Soil particle density — 2.55 gm/cc.

| Sl. No. | Depth of sampling cm. | Bulk density gm/cc | Field Capacity | Total porosity | Drainable porosity |
|---|---|---|---|---|---|
| 1. | 0 45 | 1.46 | 21.6 | 44.9 | 15.2 |
| 2. | 45— 90 | 1.53 | 19.3 | 42.3 | 15.0 |
| 3. | 90—135 | 1.55 | 19.1 | 41.5 | 14.5 |
| 4. | 135—180 | 1.68 | 16.6 | 36.6 | 12.0 |
| 5. | 180 210 | 1.68 | 18.3 | 36.6 | 10.6 |
| | Average | 1.58 | 19.0 | 40.4 | 13.5 |

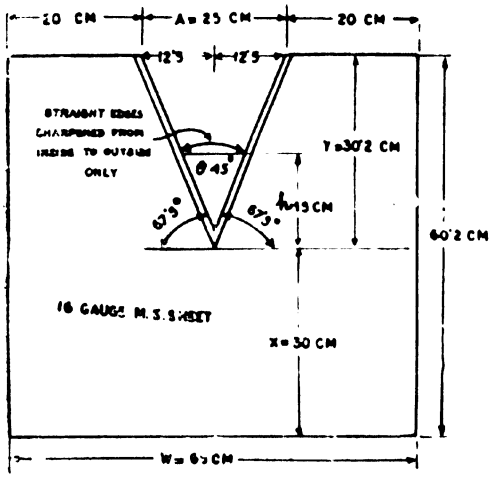
(nearly clay) was present about 3 metres below ground level. The bulk density varied from 1.46 to 1.68 gm/cc. The field capacity moisture content varied from 16.6% to 21.6%. The drainable porosity was found to be varying from 10.6% to 15.2% whereas the total porosity varied from 36.6% to 44.9%. The topography was nearly flat. On the basis of the permeability the drainage systems were designed and were laid out in the above estates. The details of the pipe drainage experiments are given in table 4.11.

**Table 4.11.** *Design details of pipe drainage experiment*

| Estate | Experimental area/ha: Control plot | Under pipe drains | length of pipe drains m. | Drain spacing m. | Drain depth m | Bed slope, per cent |
|---|---|---|---|---|---|---|
| Hunwal | 0.5 | 1.5 | 312 | 39 | 1.5 | 0.2 |
| Harroocharai | 0.5 | 0.7 | 194 | 40 | 1.2 | 0.2 |
| Mugulkata | 0.1 | 2.1 | 360 | 32 | 1.5 | 0.2 |

**Additional Points**

1. Each experiment has at least three pipe drains. The middle drain is used as experimental drain whereas the other two drains are to take care of the boundary effects.
2. The experimental drains are provided with a stilling chamber and a flow measuring device. A 45°V-notch weir is designed and fabricated for this purpose Fig 4.16.
3. A minimum of 8 cm thick layer of gravel envelope (graded gravel 3-9 mm in size) is provided around




h = 15 CM (DESIGNED FLOW HEIGHT MAXIMUM)
A = 1·5 × h = 1·5 × 15 = 22·5 CM (MIN)
X = 2 × h = 2·0 × 15 = 30·0 CM (MIN)
Y = (A/2 tan θ/2) = 30·2 CM
θ = 45°

**Fig 4.16. Design details of 45° V-Notch weir for run-off measurement.**

all the pipe drains to provide better inflow conditions and stop entry of fine materials into the drain pipes.

4. Slotted PVC pipes 3 m in length and 9 cm inside diameter are used for drains.

### (c) Optimum depth of water table

A field experiment on evaluation of the optimum depth of water table has been laid out in Tocklai tea estates with the following main objectives :

(i) To study the effect of various depths of water table on the crop yield.

(ii) To evaluate the optimum depth of water table below the soil surface to produce optimum yields.

The particle size distribution of the soil was determined by analysing samples taken randomly from five locations at a depth increment of 45 cm upto a total depth of 210 cm. The data are presented in table 4.12. The data show that the soil upto a depth of 45 cm was loamy sand whereas the soil below 45 cm was of sandy loam type.

**Table 4.12.** *Particle size distribution of soil in the experimental plot (Tocklai T.E., Section No. 2)*

| Sl. No. | Depth of soil sampling cm | Sand % | Silt % | Clay % | Textural classification |
|---|---|---|---|---|---|
| 1 | 0— 45 | 81 | 14 | 5 | Loamy sand. |
| 2 | 45— 90 | 71 | 24 | 5 | Sandy loam. |
| 3 | 90—135 | 68 | 28 | 4 | Sandy loam. |
| 4 | 135—180 | 68 | 26 | 6 | Sandy loam. |
| 5 | 180—210 | 67 | 28 | 5 | Sandy loam. |

Various soil physical properties of the soil in the experimental plot were analysed using the standard procedures. The results are presented in table 4.13.

**Table 4.13.** *Soil physical properties in the Experimental plot (Tocklai T.E.).*

Soil texture — sandy loam.
Particle Density — 2.55 gm/cc.

| Sl. No. | Depth of soil sampling cm. | Bulk density gm/cc | Field capacity | Total porosity % | Drainable porosity % |
|---|---|---|---|---|---|
| 1 | 0 — 45 | 1.50 | 15.03 | 41.17 | 18.10 |
| 2 | 45 — 90 | 1.51 | 15.68 | 40.78 | 17.08 |
| 3 | 90 — 135 | 1.51 | 17.18 | 40.78 | 15.58 |
| 4 | 135 — 180 | 1.52 | 16.85 | 40.39 | 15.59 |
| 5 | 180 — 210 | 1.54 | 18.84 | 39.60 | 13.60 |
| | Average | 1.52 | 16.72 | 40.54 | 13.99 |

The data presented in table 4.13 show that the bulk of the soil varied from 1.50 to 1.54 gm/cc. The field capacity varied from 15.03 to 18.84 per cent. The total porosity varied from 39.6 to 41.17 per cent, whereas the drainable porosity varied from 13.6 to 18.2 per cent. The impermeable layer could not be located upto a depth of 4 m and we could not go beyond 4 m because of the limitation of the equipment available. Tentatively, it is assumed that the impermeable layer in the experimental plot exists at infinite depth.

In this experiment a total number of nine pipe drains have been laid out at a fixed depth of 1.5 m below the soil surface. This experiment is divided into 3 parts.

Case 1 — Three pipe drains each 75 m long are alid at 23 m spacing.

„ 2 — Three pipe drains each 59 m long are laid at 35.5 m spacing.

„ 3 — Three pipe drains each 61 m long are laid at 46 m spacing.

Thus the drains installed at a fixed depth but varied spacings will control the water table at different depths.

All the pipe drainage experiments laid out in Hunwal, Haroocharai, Tocklai and Mogulkata tea estates will be continued for a minimum period of three years. The observations regarding the drain discharge rate and water table configurations will then be used to develop the practical recommendations regarding drain depth and spacing for different areas.

### (d) Development of cheaper concrete tiles

The PVC pipes currently being used for drainage purposes are quite expensive i.e. about Rs. 16/-per metre and are not readily available as and when needed. A project has been taken up to develop a cheaper material for drainage. A mould has been designed and fabricated at Tocklai to cast the concrete tiles of 12.5 cm inside dia-

*meter and 30 cm in length. The concrete tiles are being tested for tensile strength, crushing strength, and water absorption etc. The draining performance of such tiles will then be tested in the field condition. For this purpose an experiment has been initiated at Borbhetta T.E. this year.*

(e) **Pump Drainage Experiment**

The pump drainage experiment at Haroocharai T.E. laid out in 1976-77 is in progress. This year the size of the reservoir near pumping unit is almost doubled considering the requirement of the increased area under drainage. The main collector drain has been deepened further to carry the larger amount of flows. A brick retention wall is also provided to avoid the side collapse of the collector drain at a sharp turning point.

*Two more experiments on pump drainage in Khongia and Lengrai T.Es. laid out during 1977-78 are being continued. Results of these pump drainage experiments are awaited.*

## RESEARCH AND ADVISORY SOIL ANALYSIS

A total of 51,000 soil and plant analysis were carried out during the year. The break-up is as follows :

| | |
|---|---|
| Research | : 10,000 estimations. |
| Advisory | : 41,000 estimations. |

## METEOROLOGICAL DATA

Meteorological observations were carried out throughout the year in six class "A" observatories, namely Tocklai Thakurbari, Silcoorie, Nagrakata, Gungaram and Nagrifarm stations. Data have been processed, E.T. values by Penman's method calculated and summarised in Appendix D of this report.

## Highlights

(1) *One standard clone TV 24 with high yield potential and good cup-quality was released to the industry during the year.*

(2) *Five biclonal seed stocks found to be superior in yield and cup-quality are likely to be released in near future.*

(3) *More than 500 genetic stocks were propagated for germplasm preservation and evaluation trial.*

(4) *Photosynthetic taxonomy indicates tea to be a $C_3$ type of plant, i.e. genetically less efficient user of photosynthetic inputs like light and $CO_2$.*

(5) *Translocation studies of photosynthates using $C^{14}$ isotope indicate developing fruits and flower buds to be strong sinks.*

(6) *Large-scale field trials indicate 9.6% increase in yield of made tea (dry matter content of plucked leaf) as plucking was delayed from 7.30 a.m. to 11.00 a.m. and a further increase of 3.7% between 11.00 a.m. to 2 p.m. IST.*

## PLANT IMPROVEMENT

### Preservation of tea germplasm

The collection of tea germplasm at Tocklai consists of diverse genetic materials, more than five hundred stocks, of which 102 are seed stocks and 424 are clonal progenies of cultivated and wild *Camellia* species. Besides these, a few polyploid stocks of tea and a few other related species of *Camellia* are also being maintained in the collection. At present all these stocks are scattered in different areas at Tocklai and Borbhetta. To evaluate, preserve and utilize the germplasm collected over the years, a project was undertaken in 1978-79 to propagate about 500 genetic stocks and evaluate them for rooting ability before planting them in a long term germplasm evaluation trial.

### Biclonal stock trial

The seven biclonal stocks under long-term trial at Tocklai (Annual Report 1977-78, p.39) completed five years of testing for yield and quality. Of these, five stocks have performed significantly better than the standard varieties Tocklai stocks 203 and 449 (Table 5.01). The increase in yield of the promising stocks varied between 19.37 to 40.18 per cent over Tocklai biclonal stock 449 for the five years period and they were at par with Tocklai stock 449 in cup quality.

A decision for release of the promising Tocklai stocks is expected to be taken by the end of 1979 when the trial will complete two pruning-cycles.

Out of the five micro-seed baris established recently (Annual Report 1977-78, p.39), three are expected to produce sufficient seed next season for long-term and regional trials. The two seed baris established last season are expected to produce enough seeds for field trial by 1980-81.

**Table 5.01.** *Performance of biclonal stocks under long-term trial at Tocklai in the fifth year of testing*

| Tocklai stock. | Percentage increase (decrease) in yield over standard Tocklai stock 449 | Cup quality. Valuation in Rs./kg. | |
|---|---|---|---|
| | | CTC. | Orthodox |
| 460 | 19.37 | 8.3 | 8.3 |
| 461 | 19.55 | 7.9 | 7.8 |
| 462 | 40.18 | 8.7 | 7.9 |
| 463 | 20.73 | 7.9 | 8.2 |
| 464 | 19.85 | 8.2 | 7.9 |
| 465 | 16.74 | China hybrid stock for Darjeeling | |
| 467 | 9.71 | | |
| 449 | 0.00 | 8.0 | 8.2 |
| 203 | 16.51 | | |

### Polyploidy Breeding

The discovery of a number of aneuploid and polyploid progenies of Tocklai stock 398, which came from a triploid tea plant stock 28/2, was reported earlier (Annual Report 1976-77, p.32). About 100 seedlings were raised from the open-pollinated seeds of Tocklai stock 398. Cytological investigations show that 63 of the progenies are triploids (2n =45), two tetraploids (2n =60), two pentaploids (2n =75), three aneuploids (2n =42) and the rest are diploids (2n =30). These progenies will be evaluated for cup-quality and yield.

The triploid and tetraploid plants of Tocklai stock 398 were generally poor in their cup quality. Therefore, hybridization between the tetraploid stocks and high quality diploid clones like TV1 and TV3 and Chinery clone TV7 were undertaken from 1973-74, to produce high quality, vigorous triploids. (Annual Report 1973-74, 1974-75). All the progenies from these crosses were found to be triploids and of good vigour. For quick evaluation, these progenies were grafted on mature bushes during 1978 and 1979 for production of sufficient cuttings for planting in long-term trials.

At present a total of 116 polyploid stocks are being maintained at Tocklai represented by more than 200 living plants (Table 5.02). Detailed studies on these stocks are in progress for their use in future breeding schemes.

**Table 5.02.** *Present status of polyploid stocks maintained at Tocklai*

| Class | No. of stocks | No. of living plants |
|---|---|---|
| Triploids | 96 | 124 |
| Tetraploids | 5 | 35 |
| Pentaploids | 2 | 2 |
| Aneuploids | 12 | 32 |
| Others | 1 | 8 |

### Selection of Vegetative Clones

*During the last 10 years from 1968-69 to 1976-77 a total of 296 clones were selected for rooting trial, out of which 134 clones were planted under 12 long-term trials. Thus an average of about 30 clones were selected per year for rooting trial out of which about 13 clones were taken to the long-term trials each year.*

*Out of 134 clones under twelve long-term trials, two trials with 24 clones were completed earlier, from which six clones viz TV 18, TV 19, TV 20, TV 21, TV 22 and TV 23 were released between 1970 and 1976. One more clone TV 24 was selected for release in 1979. Rest of the clones are under various stages of trial as shown in table 5.03.*

**Table 5.03.** *Status of long-term clonal trial*

| Year of planting | No. of trials planted | No. of clones tested | Promising clones — No | Promising clones — Percent yield increase over control | Remarks |
|---|---|---|---|---|---|
| 1969 | 1 | 15 | 4 | 1.66 to 5.43 | Released as TV18, TV19 and TV20 |
| 1970 | 1 | 9 | 3 | 8.91 to 17.10 | Released as TV21, TV22 and TV23 |
| 1971 | 3 | 39 | 18 | 0.40 to 19.21 | One clone TV 24 selected for release |
| 1973 | 3 | 47 | 10 | 2.80 to 25.00 | |
| 1975 | 1 | 8 | 1 | 3.06 | |
| 1976 | 3 | 16 | 1 | 0.93 | |
| Total | 12 | 134 | 37 | — | |

### Release of Vegetative Clone TV 24

TV 24 is a standard clone, having high yield potential with good cup-quality. The characteristics of the clones are given below :

| | | |
|---|---|---|
| Category | : | Standard clone |
| Growth | : | Fast growing, vigorous |
| Frame | : | Moderately spreading |
| Leaf type | : | Light-leaf, semi-erect, medium size |
| Shoot size | : | Medium |
| Pubescence | : | Medium |
| Rooting | : | Good |
| Yield | : | Above average |
| Quality | : | Good |
| Order of preference to manufacture | : | C.T.C., orthodox |

### District Selection Scheme

The clonal selection work in the tea estates was continued during the year. The area surveyed in different districts and number of bushes selected during 19. -79 are shown in Table 5.04.

**Table 5.04.** *Number of clones selected in estates during 1978-79*

| Region | No. of estates | Area surveyed (ha) | No. of bushes selected |
|---|---|---|---|
| Assam : North Bank | 13 | 428 | 481 |
| South Bank | 3 | 94 | 111 |
| Cachar | 1 | 79 | 27 |

An area of approximately 5000 hectares in 101 estates has so far been surveyed under this scheme, from which more than 4000 mother bushes were selected. Follow-up measures were continued in all the areas. The two long-term trials established earlier at Heeleakah T.E. and Dahengiapar T.E. are progressing satisfactorily and seven more trials were established in different regions during the year (Table 5.05).

**Table 5.05.** *Long-term trials of clones from estate selection scheme*

| Region | Estates | Year of starting trial | No. of clones trial |
|---|---|---|---|
| Assam South Bank | Heeleakah | 1976 | 14 |
| Assam South Bank | Dahengiapar | 1977 | 9 |
| W. Bengal : Darjeeling | Balasun | 1977 | 6 |
| W. Bengal Dooars | Garganda | 1978 | 7 |
| Assam Goalpara | Mornai | 1978 | 8 |
| ,, ,, | Choibari | 1978 | 10 |
| ,, Kamrup | Nagrijuli | 1978 | 35 |
| ,, Cachar | Narsingpore | 1978 | 31 |
| ,, ,, | Chandighat | 1979 | 9 |

A few more trials are expected to be established during 1979-80 in different regions.

## PLANT PHYSIOLOGY

### Dry matter content

The effect of time of plucking on shoot dry matter content was investigated for the last few years and reported earlier (Annual Report 1976-77, p.35 and 1977-78, p.40-41, Proc. 28th Tocklai Conference 1977, pp. 46-50).

Results obtained from the previous investigations had shown that dry matter content of plucked shoots, which represents the recovery of made tea from green leaf, increased as plucking was delayed from 8.00 hrs through 11.00 hrs to 14.00 hrs (IST).

A large scale field experiment was conducted this year in a section of mature TV1 and J.T.C.L. 33/52 clonal teas which were left unpruned during last cold weather. Time of plucking was 07.30 hrs, 11.00 hrs and 14.00 hrs with six replications at each time. Data obtained from this experiment indicate that yield in terms of dry matter (i.e. made tea) increases when the time of plucking is delayed from 07.30 hrs to

11.00 hrs and beyond. The quantity of made tea obtained per hectare for the experimental period of mid-June to end-October at the three different hours of plucking is shown in Table 5.06.

**Table 5.06.** *Effect of plucking hour on yield, KMTH (made tea in kg/ha).*

| Clone | Made tea from green leaf plucked at | | | % increase over 7.30 a.m. yield | |
|---|---|---|---|---|---|
| | 7.30 a.m. | 11.00 a.m. | 2.00 p.m. | 11.00 a.m. | 2.00 p.m. |
| TV1 | 1762 | 1991 | 1966 | 13.00 | 11.58 |
| | | | | (1.42) | |
| J.T.C.L. 33/52 | 1237 | 1313 | 1422 | 6.14 | 14.96 |
| | | | | (8.82) | |
| Mean | 1499 | 1652 | 1694 | 10.21 | 13.01 |
| | | | | (2.80) | |

Per cent increase in yield between two adjacent time intervals, 7.30 hrs and 11.00 hrs, and 11.00 hrs and 14.00 hrs varied between the two clones. In the morning hours, yield increase of TV1 was 13 per cent compared to only 6 per cent in the *J.T.C.L.* 33/52 whereas in the afternoon hours the J.T.C.L. clone showed 9 per cent increase in yield as against no increase in TV1. It indicates a clonal difference in mobility of the photosynthates out of the leaves. Based on the average of both the clones the increase in yield during the two time intervals, 7.30 hrs to 11.00 hrs and 11.00 hrs to 14.00 hrs come to 10% and 3% respectively. This agrees with our earlier observations on shoot dry matter content.

Besides yield, the recovery percentage of made tea from green leaf at the drier mouth and the cup characters of made tea from leaves plucked at the three different times of the day were also investigated throughout the season. The mean recovery of made tea per 100 kg green leaf comes to 18.92, 18.89 and 20.60 at the three different hours of plucking when both the clones are taken together, and per cent increase of made tea between the two time intervals will be 5.12 and 3.57. The mean valuation given by the three panels of tasters shows that teas from leaves plucked at 11.00 hrs fetches higher price than the tea manufactured from leaves plucked at 7.30 hrs, but this was not consistent between tasters. The difference was 13 paise and 59 paise for TV1 and J.T.C.L. clone respectively. Details of these results are being reported by the Tea Tasting Department.

## Seasonal dormancy

To screen out the effect of ambient temperature alone on winter dormancy in tea, experiments were carried out under controlled temperature conditions in the growth room during the last few years. Results obtained from these investigations (Annual Report 1974-75, p.34; 1975-76, p.29; 1977-78, p.41) showed that flushing could be hastened by subjecting plants to mean summer temperature of 27 ± 2°C in the growth room from mid-winter when dormancy had already set in. On the other hand dormancy could be induced even in summer by subjecting plants to a low temperature of 5 ± 2 C.

Based on these findings an experiment was started to find out if winter dormancy could be prevented by high temperature treatment of plants from the early part of the winter season. Pot grown plants of clones TV1 and TV20 selected for this experiment in early November were about to complete the last flush of the season and they became dormant within about a week. Ten plants of each clone were kept in the growth room from 4th Nov. '78 to end February '79. The temperature of the growth room was maintained throughout this period at 27 ± 2°C during day and at 20 ± 2 C at night, which are comparable to mean day and mean night temperatures respectively during summer. Another group of 20 plants, 10 from each of the two clones were kept outside the growth room as control.

The plants kept in warm environment in the growth room started bud-break around early February. This means that the plants remained dormant for 12 weeks even under conditions of summer temperature. The control plants kept outside the growth room in usual cold weather did not show any sign of bud-break until the end of March, about 5 weeks after the plants in the growth room started to grow i.e. the dormancy lasted about 17 weeks.

These observations show that winter dormancy in tea cannot be completely overcome by exposing the plants to optimum temperature conditions alone. The period of dormancy can, however, be shortened by such treatment and a flush of growth can be induced about a month earlier as was observed in our previous experiments. It may be mentioned here that during a year a tea plant produced only four flushes of growth; it is rare to see five flushes produced. The number of flushes appears to be genetically controlled.

## Phasic growth

A 'bottleneck' in the movement of water and nutrients to the apical bud due to slow development of the xylem tissue inside a growing tea shoot was shown to be the probable cause of periodicity of shoot growth in tea (*Two and A bud*, 26, 1979, pp. 36-40). The length of the dormant period between two successive flushes was observed to vary between clones. This variation was suggested to be caused by unequal rates of development of the xylem tissues in different clones. The suggestion was confirmed this year by carrying out observations on four clones.

Data in Table 5.07 show per cent increase in xylem area per day in unplucked shoots during a period of dormancy and lengths of the dormant period of four clones.

Thus, there is a strong negative correlation ($r = -0.951$, $P < 0.05$) between length of the dormant period and growth rate of the xylem tissue. However, no correlation has been observed between clonal yield and length

**Table 5.07**. *Per cent increase of xylem area per day in unplucked shoots and length of dormant period between successive flushes in four clones*

| Clone | Xylem increase (% per day) | Dormant period between flushes (days) |
|---|---|---|
| TV 7 | 3.3 | 24 |
| TV16 | 3.4 | 22 |
| TV 2 | 5.3 | 20 |
| TV 9 | 6.1 | 18 |

of the dormant periods of their unplucked shoots. It is possible that repeated removal of the shoots in plucking influences the normal rate of xylem development in a clone. This possibility requires examination.

### Photosynthetic taxonomy

Twenty clones namely TV1 to TV20 were studied to explore the possibility of finding clones of higher photosynthetic efficiency.

The following observations were made :

1. Leaves of all the clones examined have veins of a lighter colour as compared to the interveinal areas.
2. Bundle sheath cells lack chloroplasts.
3. Starch grains are absent in the bundle sheath cells.
4. Carbon dioxide compensation point is more than 100 ppm.

These observations confirm the report of Rothamsted Experimental Station, Part I, pp. 37-38, 1977 that tea plant belongs to $C_3$ type which indicates that it is genetically a less efficient producer of photosynthates. No clonal difference was observed.

### Photosynthesis and respiratory losses in plucked shoots

A study was carried to find out the rates of net photosynthesis and dark respiration in the first two leaves of excised two and a bud shoots of clone TV1, and to find out whether these two leaves import food from or export it down to the lower leaves.

For finding apparent rate of photosynthesis and respiratory losses, cut shoots consisting of two leaves and bud were taken on the previous evening and arranged in small vials with the cut end of the shoot dipping in water. These shoots were left as such overnight for conditioning them to overcome the shock of excision. Next morning some shoots were shifted in dark and some kept under light to study respiration and photosynthesis respectively. Dry weight per square decimeter of two leaves of the shoot was measured in the beginning (at zero hour) and after eight hours of dark or light period. While taking measurements, apical bud and portion of the stem in between the two leaves were excluded. From data so collected the respiratory losses and apparent photosynthesis per eight hours were calculated. The sum of the two gave the actual rate of photosynthesis. Results of three experiments, conducted at 25 ± 1°C ambient temperature, are presented in Table 5.08. A major part of photosynthates is lost by way of respiration, the high rate being possibly due to excised nature of the shoots. Certainly, some photosynthates are also translocated from the two leaves to the growing bud, which has not been taken into account. As such real rates of apparent and actual photosynthesis would be slightly more than what is reported.

Likewise, another experiment was run simultaneously using long shoots, having 5 or 6 mature leaves and 2 + bud at the top, to find out the apparent rate of photosynthesis per 8 hours in the first two leaves. The difference in the apparent rates of photosynthesis of the two leaves of plucked shoots and unplucked shoots gave the amount of photosynthates translocated to these two leaves from below. Results clearly show that the two leaves of the plucked shoots always import food from below, thus confirming the observations made in previous studies.

**Table 5.08**. *Apparent photosynthesis and respiratory losses (mg/sq.dm/8 hours) in first two leaves of a growing tea shoot at 25 ± 1°C Mean of ten observations*

| Experiment No. | Plucked shoots | | | Unplucked shoots | |
|---|---|---|---|---|---|
| | Apparent photosynthesis | Respiratory losses | Actual photosynthesis | Apparent photosynthesis | Photosynthates imported |
| I | 387 | 4366 | 4753 | 2080 | 1693 |
| II | 297 | 2027 | 2324 | 2415 | 2118 |
| III | 163 | 4644 | 4807 | 1395 | 1232 |
| Mean | 282 | 3679 | 3961 | 1963 | 1681 |

### TV2 problem

Results of investigations carried out so far have been reported in Two and A Bud, Volume 26 (1) pp. 13-15, 1979. It appears that the cause for sudden death of TV2 bushes is rather physiological, because of which the plants are not able to absorb sufficient quantity of water and minerals from the soil to maintain their growth. Further experiments on grafting, pruning and correction of mineral deficiency are in progress.

### Growth regulators, yield and crop distribution

Work of last 15 years or so at Tocklai and elsewhere has clearly indicated distinct possibilities of using $GA_3$ to bring about early bud break and have an early flush. However, its use on a commercial scale has shown inconsistency in results which is likely to be due to environmental differences. Thus, irrigated tea responds more favourably to $GA_3$ (gibberellic acid) treatment than non-irrigated tea. Besides, $GA_3$ has not been successful in changing the flushing behaviour, as well as in increasing the rains and annual crop significantly. Another important factor is high cost of chemical spray. Keeping this in mind, investigations are being carried out to try combinations of growth regulators and with nutrients in different clones, so as to work out more appropriate

formulations and the right time of application to have the maximum response in the most economic way.

Further to the results reported last year (Annual Report 1977-78, p.42) it was found that foliar spraying of gibberellic acid ($GA_3$) at 50 ppm followed by 25 ppm at monthly interval from February to April increased the early (first and second flush) crop upto 25-30% in two clones TV 18 and 107/16. Spraying of growth retardants like ethrel (CEPA), cycocel (CCC) and alar (SADH) at 100 ppm for temporary suppression of rains crop indicated that ethrel was effective to suppress the heavy flush for two weeks. However, fourth or fifth week after the treatment, renewed vigour in flushing was observed in the bushes, thereby compensating the crop loss during growth suppression. The total crop of the year was not altered by the treatments. The experiment followed up during the year 1979, using the combination of $GA_3$, $GA_{4+7}$ and NAA indicated the existence of strong synergistic effect between the gibberellins $GA_3$ and $GA_{4+7}$ in promoting the early flushing.

## Photosynthesis and translocation studies using $C^{14}$ Isotope

**Relative sink capacity of aerial plant parts in a bush**: With a view to determine the relative sink capacity (capacity to store food material) of different aerial parts of an intact tea plant, a potted TV18 plant with flowers, developing fruits and axillary buds was exposed to 50 microcurie of $^{14}CO_2$, allowed to photosynthesise and translocate the photosynthates for a day. The autoradiograph of the exposed plant (Fig 5.01) showed that the actively growing axillary shoot (one and a bud) was labelled, leaving the flower buds with smaller quantity of radioactivity followed by the developing fruits. Thus sink capacity decreases in the order axillary shoots > developing fruits > flower buds. The pluckable shoots seem to be strong sinks which effectively mobilise the photosynthates. Presence of flower buds and developing fruits on a plucked bush diverts a portion of the photosynthates from the growing shoots. Hence, deblossoming or inhibition of flowering is likely to make more photosynthates available for the production of pluckable shoots.

Hand removal of flowers or use of chemicals to inhibit flowering is a possibility that should be explored for stepping up the productivity of Chinary and Cambod type of bushes during the unpruned years, when they produce flowers and fruits.

It was also observed in a TV1 bush that the developing fruits are strong sinks which draw photosynthates of source leaves from as far as 50 cm away (Fig 5.01).

**Shading of leaves on the transport of photosynthates:** The lower leaves in the canopy of a tea bush are shaded by the leaves above. Heavy shade from shade trees might also create such conditions. There is apprehension that shaded leaves of the canopy might become dependent on other leaves for food and nutrients. To verify this, an experiment was carried out on field grown bushes of clone TV20. One of the mature leaves of a shoot was shaded by black foil for varying periods extending up to a month and a nearby upper leaf was exposed to $^{14}CO_2$ and allowed to translocate the labelled photosynthates. No photosynthates were imported by the shaded leaf from the exposed leaf (Fig 5.02). It appears that mature leaves never become dependent on other leaves even under unfavourable conditions.

**Partition of reserves during spring in young tea:** Further to the results reported earlier (Annual Report 1976-77, p. 36-37) the tissue samples of the $^{14}CO_2$ exposed plants were counted in the Geiger Muller Counter and the interpretations of autoradiographs were quan-


Fig 5.01 A

Fig 5.01 B

Fig 5.02 A


Fig 5.02 B

tified. The $^{14}CO_2$ fixed by different leaves of clone TV1 are given in table 5.09.

**Table 5.09.** *Effect of leaf position (from apex) on photosynthesis by leaves of clone TV1 measured after exposure to $^{14}CO_2$ (counts/minute)*

| Leaf position | Activity |
|---|---|
| 1 | 878 |
| 2 | 1058 |
| 3 | 943 |
| 4 | 1043 |
| 5 | 879 |
| 6 | 1485 |
| 7 | 1043 |
| 8 | 1263 |
| 9 | 1490 |
| 10 | 1026 |

As the shoot was dormant at the time of exposure, leaf age did not reflect in the efficiency of $CO_2$ fixation. However low count on the first leaf may be due to its young age, and of leaf 5 may be due to shading by the upper leaves.

To study the pattern of mobilisation of reserves during the spring tissue samples of TV18 bushes exposed to $^{14}CO_2$ in December 1976 and uprooted in March 1977 (Annual Report 1976-77, p.38) were counted. Leaves of one set of plants were sprayed with $GA_3$ at 500 ppm in March, and leaves of another set were left unsprayed as control. The partition of labelled radioactivity between different parts are shown in table 5.10. The intensity in autoradiographs and counts correspond to the concentration of photosynthetic reserves in different plant organs.

**Table 5.10.** *Partition of root reserve for spring growth in Clone TV18*

| Plant part | Control plant | $GA_3$ sprayed plant |
|---|---|---|
| Leaves | 1158 cpm | 901 cpm |
| Stems | 1085 ,, | 705 ,, |
| Roots | 1003 ,, | 536 ,, |

More root reserve could be mobilised for shoot growth by spraying growth regulators like gibberellic acid on the foliage during early flush as can be seen from the reduced radioactivity in the roots of the $GA_3$ sprayed plant than in the unsprayed plant. However, further studies are required for confirmation.

## Higlights

*Micronutrients might induce rapid multiplication of red spider and other mites. Lower temperature inhibits egg laying by scarlet mite. Improvement of drainage combined with intensive insecticidal treatment reduces shot-hole borer infestations. Tomato plants were found to be a good indicator of presence of eelworms. Synthetic pyrethroids provided an effective kill of leaf eating insects. A new urea based insecticide was found to inhibit the hatching of insects eggs and prevent chitin formation. Granular formulations provide effective control of several soil borne insect pests and eelworms. Ten new insecticides were evaluated.*

### MITE PESTS

**Effect of foliar application of micronutrients on the incidence of mites :** Seasonal distribution and abundance of red spider and scarlet mite following different treatments with micronutrients were assessed. 640 leaves were sampled at random from each of the 32 plots at monthly intervals. Build up of both these two species of mites varied with the type of micronutrients, though some micronutrients were highly conducive to rapid development of mite populations. The way micronutrients influence mite reproduction is not known as yet, though it is possible that they in directly induce high multiplication rate in mites. Results of long term studies will possibly give a better understanding of the phenomenon.

**Life-study of different mites of different clones at various temperature :** Scarlet mites were raised on clones TV1 to TV10 to find out interactions between plant type and temperature, and their effects on the development of the mite.

Two series of mites under comparable conditions were maintained on leaf discs of clones TV1 to TV10 : one series was exposed to a steady temperature of 10°C, while the second was exposed to 10°C for 18 hours with a 6 hour exposure to room temperature (28.50°C) as is likely to exist in Darjeeling. Relative humidity in both the series was maintained between 75% and 80%.

At the constant temperature of 10°C, eggs were laid on none of the clones for eight weeks, but alternative temparature, however, induced egg laying (Table 6.01). Irrespective of clones, eggs were laid in a series of pulses with a wide time-gap between phases of egg laying.

Temperature is therefore a major limiting factor for mite multiplicity provided it remains steady for a long period. Survival of the mites for a period of over 10 weeks indicated a high degree of tolerance to temperature.

**Distribution of pink and purple mites on clones 1—19 :** Because of the increase abundance of pink and purple mites all over north-east India, relative susceptibility of Tocklai clones to multiple infestations of these mites was evaluated. In general, pink mite populations were higher than that of purple mite throughout the year, although the population on individual clones varied in different months. Inspite of numerical variation, seasonal population cycles of both the mites were identical : their numbers increased from April, with the rise in ambient temperature, reaching a peak in July. Thereafter, the population started declining reaching a low point in November-December.

**Table 6.01.** *Fecundity in* Brevipalpus phoenicis *Geijskes, on various clones, under a temperature regime of 10°C for 18 hrs. and exposure to room temperature for 6 hrs. with 75% to 80% R.H.*

| Clones TV | Average oviposition period (days) | Average fecundity |
|---|---|---|
| 1 | 35.6 | 3.4 |
| 2 | 29.0 | 2.8 |
| 3 | 35.2 | 6.2 |
| 4 | 41.6 | 6.0 |
| 5 | 39.0 | 6.0 |
| 6 | 35.5 | 3.5 |
| 7 | 26.0 | 2.2 |
| 8 | 38.8 | 6.8 |
| 9 | 25.4 | 2.0 |
| 10 | 28.4 | 3.2 |

The marked identical population cycle for the two species of mites is interesting, considering that pink mite is located on the undersurface of the leaf and purple on the upper surface, sometimes of the same leaf.

### SAP FEEDERS

**Bionomics of scale insects :** Irrespective of clones and jats, incidence of scale insects is on the increase on both young and mature tea, though some variation in the susceptibility of Tocklai clones is noticed. The reasons for this variability are not clear as yet. Young TV9 in particular is highly susceptible to black scale (*Chrysomphalus ficus*), though it develops resistance when it is about five years or above. TV9 shows slight to moderate susceptibility to *Fiorinia theae*, but TV1 is highly susceptible to armored scales like *Pinnaspis theae* and *Fiorinia theae*.

The developmental rate and fecundity of the diaspid scale, *Parlatoria proteus*, on TV1 and TV18 show (Table 6.02) that on TV18 the life-cycle is quicker and oviposition is more than on TV1 under comparable conditions.

The practical aspect of this finding is that severe infestation of *Parlatoria proteus* on TV18 may need more frequent insecticidal treatments than on TV1.

*Velataspis serrulata*, which was quite endemic on some clones in the last few years, was virtually absent in the experimental plots during this year. It is possible that indigeneous predators and parasites kept its population below the threshold level because no insecticidal treatment was done.

**Table 6.02.** *Life-cycle of* Parlatoria proteus *on TV1 and TV18*

| Observation period | Clones | Average number of eggs laid in life time | Average duration in days | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Egg | F (Female) / M (Male) | (Instars) 1 | (Instars) 2 | Pre-pupa | Pupa | Duration of life cycle |
| June-July | TV 1 | Not observed | 5.5 | F | 11.9 | 13.6 | — | — | 31.0 |
| | | | | M | 12.8 | 11.0 | 3.7 | 3.3 | 36.3 |
| | TV 18 | Not observed | 5.0 | F | 9.5 | 11.2 | — | — | 25.7 |
| | | | | M | 9.6 | 10.2 | 3.2 | 3.2 | 26.2 |
| Aug.-Sept. | TV 1 | 31.0 *(25.1) | 6.5 | F | 16.3 | 12.8 | — | — | 35.6 |
| | | | | M | 16.4 | 9.2 | 2.8 | 3.2 | 38.1 |
| | TV 18 | 39.0 *(32.0) | 6.5 | F | 14.1 | 10.5 | — | — | 31.1 |
| | | | | M | 14.6 | 9.8 | 3.3 | 3.1 | 37.3 |

**Figure in paranthesis is average oviposition period in days*

## LEAF EATING INSECTS

**Looper caterpillars :** Incidence of looper caterpillar (*Buzura (Biston) suppressaria* Guen) was low in the South Bank, but it caused serious damage in the Dooars and the North Bank, particularly in areas having *Indigefera teysmannii* as temporary shade. During the peaks of abundance shaded areas had on an average 815 mixed instar loopers per 50 bushes against an average of 537 in the unshaded areas. However, there was a constant inter-migration between populations in these two areas.

The incidence of bacteria and natural parasites (particularly *Apanteles*) was low in the North Bank : this caused the looper outbreak.

An estimate of the magnitude of looper population can be obtained from field collection of different developmental stages from an area of 100 acres (Table 6.03.)

**Table 6.03.** *Population of different developmental stages of Looper* Buzura (Biston) suppressaria *in 100 acres of ground surface (from random collection) during March-June, 1978*

| Developmental stages | Number collected |
|---|---|
| Moths | 110,000 |
| Caterpillars | 80,000 |
| Chrysalids | 65,000 |

**Lymantriid caterpillars :** A species of lymantriid caterpillar was endemic in some parts of Darjeeling. It has five discreet generations in a year, and therefore the damage is caused almost throughout the year : the late instars consume more than that of the early instars. These caterpillars were restricted in its distribution upto an elevation of about 1300 metres (4290 feet). The damage was more on the eastern and southern aspects.

Laboratory studies under simulated conditions showed that eggs were laid in clusters on the undersurfaces of tea leaves : each cluster had 10—30 eggs and the clusters were randomly distributed on the undersurfaces of leaves.

## SHOT-HOLE BORER

**General incidence :** Field studies on the dispersion of shot-hole borer in old tea were continued. In addition to *Xyleborus fornicatus*, *Xyleborus piceus* and *Xyleborus approximatus* reported last year, current survey shows the presensce of *X. torquatus* Eichh and *X. elegans* Samp in old tea. In most samples these two species were found on the collar region and side branches. Improvement of drainage greatly reduced the level of infestation. Intensive treatment of the affected plant parts with 0.18% concentration of Endosulfan 35 E.C. significantly reduced the infestation.

## SHADE TREE PESTS

**Biology and incidence :** An integral part of shade tree pest management is to be able to protect the young shade trees when they are most vulnerable to pest attack. A succession in the appearance of pests on young shade trees of different age group was noticeable. In two year old shade (*Albizzia odoratissima*, *A. moluccana*, *A. chinensis*, *A. procera* and *A. lebbeck*) infestations due to green flies, psyllids, and membracids were high. In shade trees of 3—5 year age-group, membracids, in addition to orange beetles and green aphids, were common.

*Indigofera teysmannii* was severely damaged by the black aphis (*Aphis crecivora*) which caused severe damage to the growing shoots, particularly leaves.

Most of the pests could be controlled by spraying any standard insecticides, but lasting control was difficult to achieve because of the rapid migration of pests. In membracid control, most of the insecticides failed to reach the insects located within the interwined foliage.

## NEMATODES

**Sampling :** The tomato, *Lycopersicum esculantum*, is a good indicator of the potential build up of nematode populations. To test this, 40 beds each measuring 1 m × 3m, were split each into two halves and were artificially inoculated with eelworms. At one of the sampling sites, a tomato seedling was directly planted, while in the other, the tomato seedling was planted in a pot filled with the soil collected from the sampling site: the pot prevented the migration of nematodes from the immediate vicinity of plants. The plants in both the series were allowed to grow for 75 days when they were pulled out and their roots were examined for root-knot infestations.

There was a good agreement between the levels of population obtained by direct soil sampling, and those from the nematode assay of the roots of the infested plants. There was no significant difference between nematode infestation on the directly planted and potted plants. In some cases the plants showed the presence of nematodes even when the conventional methods failed to extract them. Tomato plants, sown before actual tea planting, may therefore indicate the biotic potentiality for nematode growth in an area.

**Host pathogenecity :** Nematode infestation in tea has its origin in various host plants in and outside tea areas. *Meloidogyne incognita*, for example, has been found to infest *Kochia microphylla* Linn and *Moghania macrophilla*. Similarly, *Pratylenchus* spp, particularly *P. brachyurus* which causes root lesions in 3 - 4 year tea, persists on *Bambusa nana*.

Sampling shows the presence of *Helicotylenchus* on the roots of tea seedlings. This is the first time that this particular nematode has been isolated from tea roots; possibilities of a succession of nematodes in nurseries cannot be ruled out. *Helicotylenchus dihystera* live on close association with *Meloidogyne* on the root galls of tea seedlings. About 12% of the *Meloidogyne* infested seedlings were found infested with *Helicotylenchus* as well. It is possible that *Helicotylenchus* may not directly damage healthy root tissues, but could aggravate the damage already caused by root-knots.

**Egg hatchability :** The effects of soil moisture regimes on the hatchability of *Meloidogyne* eggs were evaluated : 5 egg masses freshly isolated from roots, were planted in petridishes (12 cm × 2 cm) having moisture level differentially maintained between 5% and 30% at intervals of 5%. About 50 grams of soil was kept in each petridish at the appropriate moisture level maintained by the standard weighing and replenishment method; each moisture level had 12 replications. Before setting the appropriate moisture level, the soils were steam sterilized to kill the nematodes in the soil.

Five days after the introduction of the egg masses, two petridishes were selected at random from each moisture level. The sampling was continued at 2 -3 days interval until all the petridishes could be examined. Egg hatchability was high at 5% moisture level, and none at 30% level (Table 6.04). Between 10% and 25% moisture level, the hatchability level was uniformly moderate.

**Table 6.04.** *Hatchability of the eggs of root-knots* (Meloidogyne) *at differential moisture regimes*

| Moisture level | Scoring of the quantum of eggs hatched | Remarks |
|---|---|---|
| 5 | +++++ | High hatchability |
| 10 | +++ | Moderate hatchability |
| 15 | +++ | |
| 20 | +++ | |
| 25 | +++ | |
| 30 | — | No hatchability |

## EVALUATION OF PESTICIDES

**Experimental acaricides :** Acrex (Dinobuton) 30 E.C., DPX 3792 and a nutrient-based acaricide were evaluated against laboratory populations of adult red spider mite. LD90 value for all the acaricides was obtained at a standard dilution of 1 part in 500 parts of water by volume. These acaricides were however slow acting, because a cumulative mortality of above 95% was obtained 96 hours after treatment.

Three formulations of Ethion 50 E.C. developed from indigenous resources were also evaluated against laboratory populations of adult red spiders. At 0.1% concentration, the rate of mortality increased progressively until the optimum (LD90) was reached. These formulations have therefore good residual action.

**Synthetic pyrethroids :** For the first time in tea world, the bioefficacy studies of synthetic pyrethroids against tea pests were taken up. Synthetic pyrethroid insecticides have been recently developed to deal specifically with rapidly developing insect pest populations. Synthetic pyrethroids are more toxic than conventional insecticides, yet they break down rapidly after knocking down insect populations. These compounds are photolabile and have low mammalian toxicity. The pyrethroids evaluated are

1. Permasect (Permethrin) 25 E.C.
2. Decis (Decamethrin) 2·5 E.C.
3. Permethrin (PP 557) 10 E.C.
4. Sumicidin (Fenvalerate) 20 E.C.

Their bioeffectiveness against mixed populations of looper caterpillars was assessed by treating the caterpillars at toxic levels of 0.05%, 0.05%, 0.02% and 0.04%. In all series, a 100% mortality of all stages of the caterpillars was obtained within 24 hours. These insecticides were nearly equitoxic, except that in some series, mortality was slightly delayed if the caterpillars were in the advanced stage of development. The exact relationship between the body size of the caterpillars and the activity of pyrethroids are being studied.

**Growth-inhibiting insecticide :** A new insecticides Benzophenylurea (Dimilin) 25 W.P. unconventional in the sense that it inhibits the formation of chitin on the insect cuticle, was taken up for evaluation. Apart from inhibiting the hatching of the eggs of looper, it gave a moderate control of looper caterpillars when sprayed at a concentration of 0.05%. The surviving caterpillars did not feed on the foliage.

**Microbial insecticide :** Bathucide WDP, a microbial insecticide, was sprayed at $6 \times 10^{12}$ spores/litre concentration against mixed looper populations. At this dose the mortality was low (<50%), though it was not clear if the microbe would eventually affect the physiology of surviving insects.

**Acaricides for multiple mite infestations :** Six commercial formulations of Dicofol 18.5 E.C. each at 0.09% concentration were sprayed against mixed infestations of red spider, pink, purple and scarlet mites. All resulted over 95% mortality of the mites with a variation of 5% between different series, and the plants were nearly free from any severe mite infestation for about four weeks. However, the mortality level of individual mite species was in the order, red spider > purple mite > pink mite > scarlet mite.

Six commercial formulations of Ethion 50 E.C. developed from indigeneous sources were applied at 0.25% concentration against red spider and purple mites. They were equitoxic and gave over 95% control of the adult red spider within 48 hours and over 90% mortality of purple mite in a single application. The response of the mite species varied marginally.

**New insecticides :** Pyrethroids were also evaluated for their effectiveness in controlling endemic outbreaks of an unidentified caterpillar. The compounds and their rates of application are shown in Table 6.05. Synthetic pyrethroids gave the highest mortality of nearly 100% within 24 hours. Synthetic pyrethroids have a quick knockdown effect and give the maximum mortality within the shortest possible time.

**Table 6.05.** *Comparative efficacies of synthetic pyrethroids, and a conventional insecticide against caterpillar pests of tea. Living population on 4×25 bushes*

Date of spraying : 29.3.79

| Treatments | Per cent concentration | Observation after 24 hours | | Observation after 96 hours | |
|---|---|---|---|---|---|
| | | Mean population | % reduction over pre-count | Mean population | % reduction over pre-count |
| A — Accothion 50 E.C. | 0.25 | 28.75 | 80.60 | 13.50 | 90.89 |
| B — Sumicidin 20 E.C. | 0.04 | 10.00 | 96.97 | 1.75 | 99.47 |
| C — Decis E.C. 25 | 0.005 | 18.50 | 89.02 | 2.50 | 98.51 |
| D — Permethrin 10 E.C. | 0.02 | 2.00 | 97.30 | 1.75 | 97.64 |
| E — Permasect 25 E.C. | 0.05 | 3.25 | 98.60 | 2.75 | 98.81 |
| F — Control | | 85.50 | 2.56 | 84.00 | 4.27 |
| Least significant difference at P = 0.05 | | 26.46 | — | 3.67 | — |
| C.V. % | | 63.72 | — | 11.44 | — |

Benzophenylurea (Dimilin) 25 E.C., Bromophos (Nexion) 19 E.C. and Carbamate based propoxur 25 E.C. were sprayed at concentration 2-5 times over that of pyrethroids : at this dosage level they were equitoxic to pyrethroids. 0.04% Sumicidin 20 E.C., 0.2% Permethrin 10 E.C., 0.05% Permasect 25 E.C., 0.125% Propoxur 25 E.C., 0.09% Nexion 19.5 E.C., 0.1% Lannate 20 E.C. and 0.1% Quinolphos 20 E.C. were sprayed with a mist blower against mixed infestations of different instars of looper caterpillars. Within 48 hours, Permasect gave the highest mortality closely followed by Sumicidin and Permethrin. However, after one week, all the three pyrethroids gave a near 100% mortality.

**Table 6.06.** *Comparative efficacies of Pyrethroids and several new insecticides against looper caterpillars (mixed instars) Mean looper population on 3×10 bushes per plot*

Date of spraying : 29.3.79

| Treatments | Per cent concentration | Pre-treatment count population | After 48 hrs. | | After 1 week | |
|---|---|---|---|---|---|---|
| | | | Population | % reduction | Population | % reduction |
| Sumicidin 20 E.C. | 0.04 | 51.33 | 1.33 | 98.17 | 0.00 | 100.00 |
| Permethrin 10 E.C. | 0.02 | 67.67 | 2.33 | 96.49 | 0.33 | 99.51 |
| Permasect 25 E.C. | 0.05 | 78.67 | 0.33 | 99.58 | 0.00 | 100.00 |
| Propoxur 25 E.C. | 0.125 | 74.67 | 34.00 | 54.46 | 11.00 | 85.26 |
| Nexion 19.5 E.C. | 0.09 | 79.67 | 62.00 | 22.17 | 21.67 | 72.80 |
| Lannate 20 E.C. | 0.1 | 79.33 | 34.00 | 57.14 | 9.33 | 88.23 |
| Quinolphos 25 E.C. | 0.1 | 70.33 | 24.33 | 65.40 | 8.67 | 87.67 |
| Control | — | 54.00 | 49.00 | 9.25 | 41.67 | 22.83 |
| Least significant difference at P = 0.05 | — | — | 15.04 | — | 6.24 | — |
| C.V. % | — | — | 33.10 | — | 39.21 | — |

Propoxur 25 E.C. and Lannate 20 E.C. which have residual actions, caused relatively low initial mortality. Nearly 90% mortality within a week after treatments was achieved. Nexion 19.5 E.C. gave about 73% mortality after a week, rising from low mortality of 22% in 48 hours. Performance of Quinolphos 20 E.C., was comparable with that of Lannate 20 E.C. and Propoxur 20 E.C.

**Insecticides for scale insects :** Efficacies of several new insecticides, Elsan 50 E.C., Actellic 50 E.C., Nexion 19.5 E.C., Celathion 47 E.C., and Permethrin 10 E.C., against severe infestations of black scale, *Chrysomphalus ficus* Ashm, were evaluated and compared with that of Ekalux 25 E.C and Malathion 50 E.C. The new insecticides were applied at a standard dilution of 1 part in in 200 parts of water by volume using a mist blower, twice at an interval of 20 days. At the end of one week after treatment, Celathion gave the highest mortality followed by Elsan. Performance by Permethrin and Actellic was nearly the same, Malathion and Ekalux being in the next category (Table 6.07).

A week after the second application, black scales were virtually absent in the plots treated with Permethrin, though some reinfestation occurred (through hatching of eggs) on the second week i.e. serially fourth week, after the second insecticidal treatment. The cummulative mortality increased after the second round of application though reinfestation was noticed on the fourth week.

**Table 6.07.** *Comparative efficacies of different insecticides at different concentrations against black scale* (Chrysomphalus fiscus Ashm) *of tea*

Living population of scale insects per 3 × 10 leaves

First spraying on 29.8.78
Second spraying on 19.9.78

| Treatments | Per cent concentration | Pre-treatment count Mean population | 1 week observation Mean population | % reduction | 2 week observation Mean population | % reduction | 3 week observation Mean population | % reduction | 4 week observation Mean population | % reduction |
|---|---|---|---|---|---|---|---|---|---|---|
| Ekalux EC 25 | 0.125 | 825.70 | 117.70 | 85.81 | 210.70 | 74.48 | 25.33 | 96.97 | 49.33 | 94.00 |
| Elsan 50 E.C. | 0.25 | 975.70 | 152.70 | 84.34 | 80.00 | 91.80 | 17.33 | 98.21 | 8.67 | 99.15 |
| Actellic 50 E.C. | 0.25 | 774.70 | 330.30 | 57.36 | 132.30 | 82.92 | 11.67 | 98.45 | 79.33 | 89.71 |
| Permethrin 10 E.C. | 0.05 | 771.00 | 235.30 | 69.48 | 143.70 | 81.36 | 0.00 | 100.00 | 12.67 | 98.33 |
| Nexion 19.5 E.C. | 0.097 | 375.70 | 77.00 | 79.50 | 87.30 | 76.76 | 27.33 | 92.76 | 261.00 | 30.51 |
| Celathion 47 E.C. | 0.235 | 464.70 | 32.00 | 93.11 | 28.70 | 93.82 | 9.33 | 97.93 | 66.00 | 85.74 |
| Malathion 50 E.C. | 0.25 | 546.30 | 138.30 | 74.68 | 109.30 | 79.93 | 51.33 | 90.62 | 60.67 | 88.81 |
| Control | | 554.00 | 524.70 | 4.70 | 512.70 | 7.45 | 404.67 | 26.95 | 555.33 | 0.24 |
| Least significant difference at P 0.05 | — | — | 187.04 | — | Not significant | | 147.3 | - | 265.93 | - |
| C.V. % | | — | 53.18 | — | | | 123.06 | | 111.27 | - |

**Insecticides for thrips :** Insecticides evaluated include Actellic 50 E.C., Permethrin 10 E.C., Dimilin 25 E.C. and Sevin 50 W.P. : their performance was compared against that of Endosulfan 35 E.C. These insecticides were sprayed at a dilution of 1 part in 200 parts of water using a mist blower.

Actellic and Permethrin gave over 95% mortality within 48 hours (Table 6.08) but mortality by other insecticide was on the lower side.

**Table 6.08.** *Short and long term efficacies of some new insecticides against thrips* (Taenlothrips setiventris). *Mean thrips population of 10 shoots per plot*

Date of spraying : 27.5.79

| Treatments | Per cent concentration | Pre-treatment count | After 48 hrs. Population | % reduction over pre-count | After 4 months Population | % reduction over pre-count |
|---|---|---|---|---|---|---|
| Actellic 50 E.C. | 0.25 | 10.75 | 1.00 | 96.96 | 2.75 | 74.41 |
| Permethrin 10 E.C. | 0.05 | 9.75 | 0.50 | 94.87 | 1.00 | 89.72 |
| Dimilin 25 W.P. | 0.125 | 10.50 | 1.50 | 85.76 | 1.25 | 88.06 |
| Sevin 50 W.P. | 0.25 | 9.75 | 2.25 | 76.95 | 4.25 | 56.43 |
| Endosulfan 35 E.C. | 0.175 | 11.00 | 2.75 | 75.00 | 1.25 | 88.65 |
| Control | — | 11.25 | 18.50 | -39.19 | 16.00 | -29.68 |
| Least significant difference at P 0.05 | | — | 2.06 | — | 4.00 | — |
| C.V. % | | — | 85.91 | — | 96.72 | — |

Dimilin did better. Endosulfan and Sevin were nearly equitoxic. The insecticidal treated plots were again sampled 4 months after the treatments. In Dimilin, Permethrin and Endosulfan treated plots, the level of infestation was still low, but high in plots treated with Sevin.

**Granular insecticides :** Long term trials have been laid down to test the potency of granular insecticides against termites and cockchafers. The insecticides evaluated are Carbofuran 3 G and Phorate 10 G. Preliminary results are encouraging and by next year definite trend is expected to emerge.

**Comparative efficacies of granular and emulsifiable concentrations:** Performance of granular and emulsifiable concentrates of insecticides against cockchafers was evaluated. The emulsifiable concentrates (EC) used were Quinolphos 25 E.C., Phenthoate 50 E.C., Endosulfan 35 E.C., and X-factor, while the granular formulations were Phorate 10 G and Carbofuran 3 G. E.C. formulations were applied at 1 in 500 parts of water and the granular formulation at the rate of 10 g per plant.

**Table 6.09.** *Comparative efficacies of different granular and emulsifiable concentration of insecticides against cockchafer* (Phyllophaga seticollis)

| Treatments | % bushes attacked three months after treatments | Degree of cockchafer damage |
|---|---|---|
| Quinolphos 25 E.C. | 8.33 | 0.08 |
| Phenthoate 30 E.C. | 16.68 | 0.20 |
| X-factor | 14.67 | 0.18 |
| Endosulfan 35 E.C. | 11.67 | 0.18 |
| Phorate 10 G | 10.67 | 0.20 |
| Carbofuran 3 G | 10.02 | 0.14 |
| Control | 25.00 | 0.33 |
| Least significant difference at P = 0.05 | 10.72 | 0.15 |
| C.V. % | 40.91 | 47.37 |

Three months after the treatment (Table 6.09), quinolphos treated plants were least attacked, but both the granular formulations gave slightly higher protection from Cockchafer damage than other insecticides.

**Nematicides :** Palliative control of the root knot nematode (*Meloidogyne incognita* Chitwood) was attempted using granular nematicides, Aldicarb 10 G, Carbofuran

3 G, Phorate 10 G and Mocap 10 G. The rates of application are shown in Table 6.10. Nematicides were applied around the collar region of the plants by slightly forking them into the soil followed by slight sprinkling of water. 90 days after application, the number of nematodes in the soil samples from the treated plots was assessed along with the growth of the plants.

**Table 6.10.** *Effect of nematicides on Root-knot* (Meloidogyne *sp*) *population, and growth of infested tea seedling*

| Nematocides | Application rate (g)/ plant | Larval mortality % in soil | Shoot growth cm | Percentage of transferable plants |
|---|---|---|---|---|
| Aldicarb 10 G | 1.00 | 59.51 | 17.43 | 61.33 |
| Aldicarb 10 G | 0.5 | 59.93 | 14.96 | 49.25 |
| Carbofuran 3 G | 1.0 | 65.34 | 19.75 | 69.25 |
| *Carbofuran 3 G | 2.0 | 77.38 | 20.68 | 70.85 |
| Mocap 10 G | 1.0 | 68.28 | 17.97 | 45.94 |
| Thimet 10 G | 0.1 | 43.50 | 10.73 | 43.00 |
| Control | — | 47.33 | 16.09 | 44.37 |

*Split dose of 1 gm at one month interval

Split application of Carbofuran at 1 g/plant at interval of a month, gave the maximum mortality. Mocap and Carbofuran at 1 g per plant were equitoxic, followed by Aldicarb. Thimet gave the least control. The increase in shoot length following nematicidal treatments did not follow a definite trend though in Carbofuran treated plots the number of transferable plants was high.

**Pesticide residues :** Samples of processed and sundried tea treated with different dilutions of Permethrin 10 E.C., Elsan 50 E.C. and Calixin 75 E.C. were prepared both during the wet and dry seasons. These samples are now being analysed to determine the levels of residues of these pesticides.

**Pesticides tainting :** Twentyseven formulations of different acaricides and insecticides were evaluated for their tainting effects. The Tea Taster detected varying degrees of taints in teas treated with Sevin 50 W.P., Dimecron 100 E and in one formulation of Teepol and Bathucide.

## PEST SURVIELLANCE

Monitoring of insects, mites and eelworms on tea and shade trees was continued. Species of insect recorded for the first time are listed in Table 6.11.

## CERTIFICATION PROGRAMME

40 formulations of pesticides were accepted for evaluation. 7 Certificates of approval were issued after completion of appropriate tests.

**Table 6.11.** *New records of insects from tea and shade trees during 1978-79*

| Name | Host | Order/family |
|---|---|---|
| *Xyleborus torquatus* Eichh | Tea | Coleoptera/Scolytidae |
| *X.* sp. nr. *elegans* Samp. | ,, | ,, / ,, |
| *Ernoporus* sp. | *Derris robusta* | ,, / ,, |
| *Verania discolor* | | Coleoptera/Coccinellidae |
| *Brumoides suturalis* | *A. moluccana* | ,, / ,, |
| *Polyura aria* Feld. | *A. odoratissima* | Lepidoptera/Nymphalidae |
| *Spodoptera litura* F. | Tea | ,, /Noctuidae |
| *Diarsia ochracea* Walk. / *Elydra nonagrica* Walk. | Tea | ,, / ,, |
| *Chionaema peregrina* Walk | *D. robusta* | ,, /Artiidae |
| *Oligochroa* sp. | *A. procera*/*A. moluccana* | ,, /Pyralidae |
| *Servillea sobria* (Wlk) | *A. bipunctata* | Diptera/Tachinidae |
| *Ricania speculum* (Walker) | *A. odoratissima* | Homoptera/Ricariidae |
| *Coelophora biplagiata* | *Chrysomphalus ficus* | Coleoptera/Coccinellidae |
| *Chilocorus circumdatus* Sch. | ,, ,, | ,, / ,, |
| *Chilocorus nigritus* (F) | ,, ,, | ,, / ,, |
| *Apterencyrtus microphagus* (Mayr.) | ,, ,, | Hymenoptera/Encyrtidae |
| *Comperiella bifasciata* Howard | ,, ,, | ,, / ,, |
| *Marietta javensis* (Howard) | ,, ,, | , /Aphelinidae |
| *Aspidiotiphagus* sp. | ,, ,, | ,, / ,, |
| *Arrhenophagus chionaspidis* Aurivillius | *Pinnaspis theae* | ,, /Encyrtidae |
| *Xenocatantops humilis* (Serville) | Tea | Orthoptera/Acrididae |

## QUALITY CONTROL OF PESTICIDES

33 samples of acaricides and insecticides were received from tea estates for testing their potencies. Bioassay with these samples were done and reported. 6% samples were below the expected standard.

## ADVISORY SERVICES

993 samples of plants affected by pests were examined, and the report suggesting measures of control were sent. 2012 soil samples were examined of which 15.85% were rejected because they were found having high eelworm population and hence unsuitable for nursery.

The Assistant Entomologist, Nagrakata, senior staff of entomology Department and Head of Entomology Department visited different tea estates to advice on various pest problems and their control. 8 advisory leaflets and tea encyclopaedia serials on the control of major tea pests were prepared.

## GENERAL

Dr. D. Saharia of the Department of Entomology, Assam Agricultural University, was admitted to Ph.D. degree of Assam Agricultural University. Dr. Saharia carried out research on bioecology of some important coccinellid predators of aphids and integrated control, under supervision of Dr. B. Banerjee, at Tocklai and at Assam Agricultural University.

## Highlights

*Among the new fungicides tried Copcide for red rust control, Delan for black rot control, Fungikill and Tamraghol for blister blight control were effective. Antibiotics (Agrimycin and Plantomycin) as additives to copper fungicides had little influence on red rust and black rot control, but may have a role in blister control. Sequential spray of fertilisers, MOP and Urea, singly or in combination, prior to copper fungicide application, effectively reduced the disease incidence of red rust.*

*Application of Simazine to soils adversely affected the nitrifying bacteria and lead to accumulation of nitrite, but stimulated fungi which aid in nitrification. Organic matter additions lessened the inhibitory effect.*

*Charcoal stump rot organism has high survival potential due to low nutritional requirements and hence needs special care for arresting its spread.*

*Tea roots harbour VA mycorrhiza which assist in P absorption. The VA mycorrhiza were found to occur in tea root during the dry season but were absent in the rainy months when they were found in the associated weeds.*

*Long term studies on sporulation pattern and effect of lower dilution of copper fungicides have shown that for effective control of red rust a dilution of 1 : 1000 sprayed in six fortnightly rounds was most suitable.*

## Fungicides

During the year twentytwo formulations were under study for their efficacy in controlling red rust, *Poria* stem disease, black rot and blister blight. These included a wide range of organic, metallic and systemic fungicides, antibiotics which were incorporated in copper fungicide sprays to study their synergistic action. In addition, observations continued on areas where seven other chemicals mostly soil fumigants were applied against primary root diseases.

## Red rust

Experiments during the year were conducted to study three aspects (a) screening of new fungicides for control of the disease, (b) antibiotic additives to copper fungicides and (c) fertilizer applied as foliar sprays prior to copper fungicide spray. There were four trials on different locations all in Jorhat area.

### Screening trials

Screening trials were undertaken to set new fungicide formulations on two locations I and II. On location I the clonal tea was carrying severe infection by red rust. Delan, Saprol and F.M. Spray 77 were tested for the first time at the rates suggested by the formulators. Dithane M-45, an improved version of the old preparation was tried at lower concentration. Fytolan was used as a standard fungicide for comparision on location II. Delan and Saprol were omitted and Captan was added as a treatment. Four rounds of spray were imparted with hand operated bakpak sprayers. Interval between the first two round spray was fourteen days and the subsequent two a month each. The overall control was assessed by visual scoring of all the bushes from the plots excluding the guard rows on the usual 0-4 scale. The details about bush population, age etc., and full results are given in Appendix 7a and b—extracted results in Table 7.01.

**Table 7.01.** *Red rust control achieved under various fungicidals sprays on 2 locations in Jorhat circle (Degree of control is measured as percentage reduction in infection over control plots on 0-4 scoring)*

| Fungicides | Location I* | Location II* | Average |
|---|---|---|---|
| Fytolan 1:400 | 89.0 | 92.3 | 90.7 |
| Copcide 1:400 | 85.8 | 92.3 | 89.1 |
| Dithane M-45 1:1000 | 23.1 | 26.2 | 24.7 |
| F.M. Spray 1:200 | 71.2 | 58.5 | 64.9 |
| Delan 1:1000 | 14.2 | - | 14.2 |
| Saprol 1:1000 | 8.2 | - | 8.2 |
| Captan 1:400 | - | 30.8 | 30.8 |
| C.D. at P 0.05 | 10.0 | 14.6 | |
| C.V. % | 11.68 | 19.82 | |

*see appendix 7a
**see appendix 7b

**Appendix 7a**

*Degree of red rust infection and disease control (Mean of 384 bushes) with new fungicides in screening trial.*

| Treatments | Rate | Incidence per bush | % reduction over control |
|---|---|---|---|
| 1. Delan | 1:1000 | 2.41 | 14.23 |
| 2. Saprol | 1:1000 | 2.58 | 8.19 |
| 3. Copcide | 1:400 | 0.40 | 85.77 |
| 4. F.M. Spray | 1:200 | 0.81 | 71.17 |
| 5. Dithane M-45 | 1:1000 | 2.16 | 23.13 |
| 6. Fytolan (standard) | 1:400 | 0.31 | 88.97 |
| 7. Control (unsprayed) | | 2.81 | |
| C.D. at P 0.05 | | 0.28 | |
| C.V. % | | 11.68 | |

Age of tea : 4 years clones
Spacing : 120×60×60 cm double hedge
Plot size : 96 bushes per plot excluding guard line 4 replicates
Date of spraying... Between 19.5.78 and 2.8.78

The new formulation Copcide was found to be as efficient as the standard fungicide Fytolan. F.M. Spray was superior to other fungicides tested but it was significantly inferior to Copcide and Fytolan.

### Antibiotic additives to copper fungicides

Two trials were laid out in one of which the effect of antibiotic additives to copper fungicides was investigated while the other was a screening trial to compare the effect of additives along with other formulations.

In the first trial Agrimycin 100 (Pfizer) and Plantomycin (Aries Agrovet) were added at 100 and 200 ppm levels on a dilution of 1:1000 copper fungicide. In the second trial in addition to the above treatments, other formulations were also tested but without antibiotic addi-

tives. Four rounds of spray were imposed using hand operated bakpak sprayers. Details of bush population, age etc. are given in Appendix 7b and 7c and extracted results in Table 7.02.

**Table 7.02.** *Impact of antibiotic additives to fungal spray on degree of red rust control on 2 locations in Jorhat circle*

| Fungicide: Fytolan + 1:1000 | | Location I* | Location II** | Average |
|---|---|---|---|---|
| Agrimycin | 0 ppm | 75.0 | 59.2 | 67.1 |
| | 100 ppm | 77.6 | 59.2 | 68.4 |
| | 200 ppm | 75.9 | 55.4 | 65.6 |
| Plantomycin. | 0 ppm | 75.0 | 59.2 | 67.1 |
| | 100 ppm | 74.1 | 55.4 | 64.8 |
| | 200 ppm | 75.9 | 61.5 | 68.7 |
| Fytolan 1:400 (standard) | | 91.4 | 92.3 | 91.9 |
| C.D. at P 0.05 | | 12.1 | 14.6 | |
| C.V. % | | 25.25 | 19.82 | |

* for details see appendix 7c
** for details see appendix 7b

**Appendix 7b**

*Degree of red rust infection per bush and percentage of the disease control (Mean of 120 bushes)*

| Treatments | Rate | Infection intensity per bush. | % reduction over control |
|---|---|---|---|
| 1. Control (unsprayed) | - | 1.30 | — |
| 2. Fytolan | 1:400 | 0.10 | 92.31 |
| 3. Fytolan | 1:1000 | 0.53 | 59.23 |
| 4. Fytolan + Agrimycin | 1:1000+100 ppm | 0.53 | 59.23 |
| 5. Fytolan + Agrimycin | 1:1000 + 200 ppm | 0.58 | 55.38 |
| 6. Fytolan + Plantomycin | 1:1000+100 ppm | 0.58 | 55.38 |
| 7. Fytolan + Plantomycin | 1:1000+200 ppm | 0.50 | 61.54 |
| 8. Dithane M-45 | 1:1000 | 0.96 | 26.15 |
| 9. F.M. Spray 77 | 1:200 | 0.54 | 58.46 |
| 10. Copcide | 1:400 | 0.10 | 92.31 |
| 11. Captan | 1:400 | 0.90 | 30.77 |
| C.D. at P = 0.05 | | | |
| C.V. % | | 0.19<br>19.82 | |

Age : 8 years old tea — unshaded
Spacing : 120×90×90
Plot size : 30 bushes excluding guard lines 4 replicates
Spraying time : Between 18.5.78 and 22.7.78

**Appendix 7c**

*Mean degree of incidence of red rust per bush and effect of antibiotics in control (average of 204 bushes)*

| Treatments | Rates | Mean degree of incidence per bush. | % reduction over control |
|---|---|---|---|
| 1. Fytolan | 1:1000 | 0.29 | 75.00 |
| 2. Fytolan | 1:1000 + Agrimycin 100 ppm | 0.26 | 77.59 |
| 3. ,, | 1:1000 + Agrimycin 200 ppm | 0.28 | 75.86 |
| 4. ,, | 1:1000 + Plantomycin 100 ppm | 0.30 | 74.14 |
| 5. ,, | 1:1000 + Plantomycin 200 ppm | 0.28 | 75.86 |
| 6. ,, | 1:400 | 0.10 | 91.38 |
| 7. Control (unsprayed) | | 1.16 | |
| C.D. at P = | 0.05 | 0.14 | |
| C.V. % | | 25.25 | |

Age of tea : 6 years old clonal tea.
Spacing : 60×60×80 triple hedge.
Plot size : 51 bushes each plot excluding guard line
Date of spraying : Between 24.5.78 and 4.8. 78

Addition of antibiotics to the conventional copper fungicide has not in any way given superior performance. Copper fungicide at 1:400 is by far the best when used alone. Added Agrimycin and Plantomycin at 100 and 200 ppm did not show any advantage in the degree of control offered.

## Fertiliser spray before fungicides on Red rust control

This investigation was aimed at evaluating the beneficial effect, if any, of foliar application of urea and muriate of potash singly or in combination, prior to application of a standard copper fungicide on severe red rust infected plants during the sporulating period of the alga. The experimental area consisted of four year old clonal plants at 120×60×6 cm spacing which were grouped in three blocks of eight plots each, each plot containing fifty plants. There were eight treatments including unsprayed control. Four applications were made during the period between 19.5.78 and 2.8.78 using hand operated Bakpak sprayers. In treatments where both foliar fertilizers and fungicides were to be applied, the fertilizer was sprayed first and the fungicide was applied one hour later. The overall effects of the treatments were assessed and the intensity of infection per bush as recorded in 0—4 scale of severity is presented in Table 7.03 and Appendix 7d.

**Table 7.03.** *Degree of red rust control by sequential spray of fertilizers and fungicides (% over disease incidence in no spray control plots on 0-4 scale)*

| Fungicide | Fertilizers | | | |
|---|---|---|---|---|
| | None | Urea 4:100 | MOP 4:100 | Urea + MOP 2:100 2:100 |
| None | 0 | 18.1 | 24.4 | 32.4 |
| Fytolan 1:400 | 74.3 | 92.1 | 92.7 | 94.9 |
| Additional control of Red rust with fertilizer incorporation. | - | 17.8 | 18.4 | 20.6 |
| C.D. at P = 0.05 | | | 16.51 | |
| C.V. % | | | 20.43 | |

**Appendix 7d**

*Mean degree of red rust infection per bush and percentage of the disease control (Mean of 150 bushes)*

| Treatments | Rate | Mean infection intensity per bush. | % reduction over control |
|---|---|---|---|
| 1. Urea | 4:100 | 2.58 | 18.10 |
| 2. Muriate of potash | 4:100 | 2.38 | 24.44 |
| 3. Urea + Muriate of potash. | 2:100+2:100 | 2.13 | 32.38 |
| 4. Fytolan | 1:400 | 0.81 | 74.29 |
| 5. Urea + Fytolan | 4:100+1:400 | 0.25 | 92.06 |
| 6. Muriate of potash + Fytolan. | 4:100+1:400 | 0.23 | 92.70 |
| 7. Urea + Muriate of potash+Fytolan. | 2:100+2:100 +1:400 | 0.16 | 94.92 |
| Control (unsprayed) | | 3.15 | |
| C.D. at P = 0.05 | | 0.52 | |
| C.V. % | | 20.43 | |

Incorporating Urea, MOP and MOP + Urea with copper fungicides had an additional significant advantage in disease control.

It is evident that foliar application of Urea and Potash alone or in combination results in significant reduction in disease intensity. Their application, preceding fungicide spray did result in improved performance by the fungicide. The fungicide when sprayed alone reduced red rust incidence by 74% while its performance improved to 92 to 95% in Urea and Potash sprayed plots (Table 7.03 and Appendix 7 d).

## Black rot

During the year two field experiments were conducted in Upper Assam, one was to screen different proprietory products for their efficacy in controlling the disease and second one was to look for any synergistic action of two antibiotics when applied in combination with a copper fungicide.

## Comparison of fungicides for black rot control

Six fungicides were tried against black rot in a youngish mature tea area in a garden in Margherita circle. The tea was attacked by both the species of black rot causing fungi, *Corticium invisum* and *C. theae*. The disease was late in coming up and the treatments were applied in two rounds on 29.5.78 and 12.6.78 with hand operated Bakpak sprayers. The experimental area consisted of four blocks of seven plots, each plot containing thirtyfive bushes. The plots were separated by guard lines which received the spray as the adjoining plots but were not scored for black rot incidence. Individual bushes in the treated plots were examined for the degree of incidence of the disease in the 0-4 scale of severity and the results are given in Table 7.04.

**Table 7.04**. *Mean degree of black rot infection per bush and percentage of disease control (Mean of 140 bushes)*

| Treatments | Rate | Mean degree of infection per bush | % reduction over control |
|---|---|---|---|
| 1. Fytolan (standard fungicide) | 1:400 | 0.36 | 85.77 |
| 2. Dithane M-45 | 1:1000 | 1.31 | 48.22 |
| 3. F.M. Spray 77 | 1:200 | 1.34 | 47.04 |
| 4. Copcide | 1:400 | 0.74 | 70.75 |
| 5. Delan | 1:1000 | 0.66 | 73.91 |
| 6. Saprol | 1:1000 | 1.74 | 31.23 |
| 7. Control (unsprayed) | | 2.53 | |
| C.D. at P = 0.05 | | 0.34 | |
| C.V. % | | 18.66 | |

Apart from the standard fungicide, Copcide and Delan affected appreciable control of the disease. Delan is claimed to possess redistribution properties and needs further trial under different agroclimates. Redistribution is a phenomenon by which the fungicide active ingredients after forming a deposit on the plant, gradually absorb moisture from rain and dew and spread to give protection to new growth.

## Antibiotic additives to copper fungicides

This experiment was identical with the additive experiment for red rust control and was meant for evaluating synergistic action of the Agrimycin and Plantomycin when applied with a lower dilution of a standard copper fungicide Blitox. The experiment was laid out in a commercial garden in Upper Assam; *Corticium invisum* was causing black rot. There were altogether seven treatments, replicated four times with twentysix bushes per plot. The disease was very late in its build up and the two sprays were applied on 13.6.78 and 27.6.78 using Bakpak sprayers. The results were assessed as usual and presented in Table 7.05.

**Table 7.05**. *Mean degree of black rot infection per bush and percentage of disease control (Mean of 104 bushes)*

| Treatments | Rate | Mean infection per bush | % reduction over control |
|---|---|---|---|
| 1. Blitox | 1:400 | 0.73 | 72.86 |
| 2. Blitox | 1:1000 | 1.15 | 57.25 |
| 3. Blitox + Agrimycin | 1:1000 + 100 ppm | 1.20 | 55.39 |
| 4. Blitox + Agrimycin | 1:1000 + 200 ppm | 1.33 | 48.70 |
| 5. Blitox + Plantomycin | 1:1000 + 100 ppm | 1.41 | 47.58 |
| 6. Blitox + Plantomycin | 1:1000 + 200 ppm | 1.43 | 45.84 |
| 7. Control (unsprayed) | | 2.69 | |
| C.D. at P = 0.05 | | 0.36 | |
| C.V. % | | 16.85 | |

There was no significant benefit in application of Agrimycin or Plantomycin in increasing the efficacy of the fungicide tested, even in black rot control.

## Blister blight

During 1978 two field experiments were conducted in Darjeeling. One of these experiments was the continuation of an experiment laid out in 1976 to compare a number of fungicides and test a binder additive. The other experiment was a routine investigation to test the efficacy of a number of new fungicides in mitigating the blister blight : two antibiotics (Agrimycin and Plantomycin) were also included in this experiment to study their synergistic action when applied in combination with a copper fungicide.

## Fungicides with and without binders

As in the previous years a number of new fungicides were compared at the rates suggested by the formulators. Mowlith, an acrylic binder (Hoechst) was suggested to be used with Calixin (BASF) for better tenacity and long term effects at different levels. Treatments were applied as soon as the disease was observed in the experimental plots. The spraying was done at weekly and biweekly intervals (Calixin) till the end of the blister season in 1978. This experiment designed to evaluate the effects of the treatments on yield will be carried through a complete pruning cycle.

The effect of treatments on the incidence of blister blight as recorded after the 4th round of spraying is shown in Table 7.06 and Appendix 7e.

All the four copper formulations gave significantly better control than the rest of the treatments viz. Calixin and M.B.C.

The yield records will be summarized on the conclusion of the experiment.

**Table 7.06.** *Effect of fungicides in blister blight control*

| Fungicide dose | Percentage reduction in blister blight. | | |
|---|---|---|---|
| | 1976 | 1977 | 1978 |
| Blitox 625 g/ha | 75.28 | 80.45 | 80.95 |
| Fungikill ,, | 75.83 | 71.47 | 80.73 |
| Tamraghol ,, | 74.50 | 72.43 | 77.33 |
| Copper oxy- ,, chloride | 79.49 | 77.88 | 91.84 |
| Calixin 1:200 ml/ha Mowlith 2 | 42.02 | 52.57 | 36.73 |
| Calixin 1: ml/ha Mowlith 3 | 21.73 | 48.08 | 52.38 |
| Calixin 1: ,, Mowlith 4 | 31.71 | 32.69 | 51.02 |
| MBC 625 g/ha | | 0.96 | 19.05 |
| C.D. at P = 0.05 | 25.00 | 23.62 | 23.21 |
| C.V. % | 25.08 | 24.43 | 28.17 |

**Appendix 7e**

*Effect of treatments on control of blister blight*

| Treatments | Rate/ha | Interval in days | Rounds | No. of blisters per 100 shoots | %reduction over-control |
|---|---|---|---|---|---|
| 1. Blitox | 625 g | 7 | 5 | 28.00 | 80.95 |
| 2. Fungikill | 625 g | 7 | 5 | 28.33 | 80.73 |
| 3. Tamraghol | 625 g | 7 | 5 | 33.33 | 77.33 |
| 4. Copper oxychloride | 625 g | 7 | 5 | 12.00 | 91.84 |
| 5. Calixin 1: Mowlith 2 | 200 ml | 14 | 3 | 93.00 | 36.73 |
| 6. Calixin 1: Mowlith 3 | 200 ml | 14 | 3 | 70.00 | 52.38 |
| 7 Calixin 1: Mowlith 4 | 200 ml | 14 | 3 | 72.00 | 51.02 |
| 8. M.B.C. | 625 g | 14 | 3 | 119.00 | 19.05 |
| 9. Hard plucking (weekly throughout observation) | | | | 103.38 | 29.67 |
| 10. Control | | | | 147.00 | |
| C.D. at P = 0.05 | | | | 34.12 | |
| C.V. % | | | | 28.17 | |

## Screening of fungicides with antibiotic additives

Five new fungicides and two antibiotics were included in the screening trial during 1978.

The antibiotics Agrimycin and Plantomycin were incorporated with copper fungicide and their possible synergistic action was studied.

There were altogether 11 treatments including an untreated control. The treatments were applied in plots of 30 bushes randomized in 3 replicates. The treatments were administrated at weekly interval immediately following each plucking round. The number of blisters on the 3rd leaf in 100 shoots collected at random from bulked plucking from each plot was recorded every week.

The final observations made one week after the application of the last round is given below in the Table 7.07

**Table 7.07.** *Effect of different fungicides and antibiotics on the control of blister blight*

| Treatments | Rate | Spraying interval in days | Rounds | Blister per 100 shoots | % reduction over control |
|---|---|---|---|---|---|
| 1. Control | | | | 61.00 | |
| 2. Blitox | 625 g/ha | 7 | 4 | 7.33 | 87.98 |
| 3. Blitox + Agrimycin | 625 g/ha + 100 ppm | 7 | 4 | 3.33 | 94.54 |
| 4. Blitox + Agrimycin | 625 g/ha + 200 ppm | 7 | 4 | 4.33 | 92.90 |
| 5. Blitox + Plantomycin | 625 g/ha + 100 ppm | 7 | 4 | 6.67 | 89.07 |
| 6. Blitox + Plantomycin | 625 g/ha + 200 ppm | 7 | 4 | 4.00 | 93.44 |
| 7. Copcide | 625 g/ha | 7 | 4 | 17.67 | 71.03 |
| 8. Dithane M-45 | 1:1000 | 7 | 4 | 33.33 | 45.36 |
| 9. Delan 75 WP | 1:1000 | 7 | 4 | 15.33 | 74.87 |
| 10. Saprol | 1:1000 | 7 | 4 | 13.67 | 77.59 |
| 11. F.M. Spray | 2.5 kg/ha | 7 | 4 | 9.33 | 84.70 |
| C.D. at P = 0.05 | | | | 11.97 | 19.62 |
| C.V. % | | | | 43.9 | 43.9 |

With the exception of Dithane M-45 all other fungicides tested afforded significant reduction of the disease. Control of blister blight with antibiotics in combination with copper indicated a slight synergistic action between the copper and antibiotics but it was not manifested at a significant level. For blister blight control in Darjeeling area the antibiotic additives to copper fungicides using lower doses of copper is contemplated.

## SOIL MICROBIOLOGY

### Effect of agrochemicals on autotrophic nitrification

Among the biochemical reactions of importance to soil fertility, nitrification is one of the most sensitive to agricultural chemicals. Nitrification in soil is attributed largely to the action of chemoautotrophic nitrifying bacteria. A doubt, however, exists if the chemoautotrophs are solely responsible for nitrification in acid soils. Recent evidences also indicate instances of occurrence of heterotrophic nitrification in cultures of microorganisms and in natural ecosystems. Since tea soil is highly acidic, it was thought worthwhile to investigate the effect of agrochemicals on autotrophic and heterotrophic nitrifiers, if at all they occur in tea soil.

The effect of Simazine was investigated in greater detail, though other agro-chemicals Diuron, Endosulfan, Copper oxychloride and Metham sodium were employed. Effect of agrochemicals on autotrophic nitrification was studied using pure cultures of *Nitrosomonas* and *Nitrobacter* sp. isolated from tea soil. Considerable variation was observed in nitrification following application of agricultural chemicals. Detailed studies on Simazine were

carried out. Nitrite was found to be accumulated due to application of simazine. Simazine was also found to reduce the number of *Nitrobacter* sp.

By enrichment culture technique, *Penicillium* spp., *Trichoderma viride*, *Fusarium* sp., *Aspergillus niger*, *Absidia* sp. and two gram negative bacteria were isolated from simazine applied soil. On biochemical and physiological tests, the bacteria were identified as *Flavobacterium* sp. and *Pseudomonas* sp. It was observed that some of the fungi possessed the ability to nitrify. It may therefore be concluded that simazine stimulated heterotrophic nitrification probably by stimulating these organisms.

Studying the effect of organic amendments and their interactions with agrochemicals, it was seen that the addition of organic matter lessened the inhibitory effect of all agrochemicals studied on microorganisms, perhaps due to adsorption.

**Microbial degradation of simazine**

The above isolates of microorganisms obtained by enrichment culture technique were employed for microbial degradation in synthetic media and soil.

Simazine residue extracts with its degradation products were spotted on thin layer chromatograms in different solvent systems. Five metabolites of the simazine residue have been confirmed. These degradation products are yet to be identified.

**Root rots**

Ecology of Charcoal stump rot fungus *Ustulina zonata* was investigated. The organism survives severe interfungal interaction in soil and the consequent toxic metabolites secreted by them. To determine the reasons for its strong survival potential, interfungal competition was studied and its nutritional requirements were found to be very low as it could grow well on sterile filter paper. Its cellulotysis adequacy index is low, suggesting its survival ability regardless of the nitrogen status in the soil.

**Mycorrhiza**

Screening roots at various periods of the year revealed that during the months of April/May and November/December the white feeder roots frequently showed the presence of vesicles and arbuscles which are the survival mechanism for endomycorrhizae. In contrast to this during the period of heavy rainfall in July/August, the tea roots did not show the occurrence of arbuscles and vesicles with marked frequency though fungal structures could be observed. Further, a brown fungus was seen on the roots during the monsoon season.

The roots of weeds persistently showed the presence of endotrophic mycorrhiza. Roots of *Axonopus compressus* showed higher-frequency infection. During the monsoon season also the roots of weeds were seen to be infected by the endotrophic mycorrhizas.

Screening of soil around the tea roots showed the presence of four types of spores resembling those of VA mycorrhiza. They are:

(a) a large yellow coloured spore with bulbous base.

(b) a brown coloured thick walled spore.

(c) a white fleshy structure resembling the sporocarp of *Endogone* sp.

(d) a black spherical spore attached to a thin aseptate hyphae.

## IMPORTANT CONSIDERATIONS ON FREQUENCY AND DILUTION OF FUNGICIDAL SPRAY FOR RED RUST CONTROL

Prior to 1966 two rounds of spray at 1:400 dilution were given for significant red rust control. In 1967 the epidemiology of red rust was studied. The red rust alga *Cephaleuros parasiticus* produces fruit bodies on sporangia which normally mature in 14-15 days : 6 to 8 batches of sporangia are produced in a season. Consequently, the spore discharge showed typical peaks and troughs till third week of August. However, the germinability of the spores fell sharply after 10th August. This showed the need of applying copper fungicide in more than two rounds. However, copper fungicides have a depressing effect on the crop if sprayed in more than four rounds at 1:400 dilution which has been well documented. If the tea bush is to be protected during the entire sporulating spell of red rust alga, then six rounds of copper spray are necessary at fortnightly intervals.

In view of these divergent needs of frequency and limit on copper, the lower dilutions and more number of rounds were tried. A dilution of 1:1000 was found to produce an acceptable control of the red rust disease during each spray. Thus 1:1000 dilution sprayed 6 times at fortnightly interval protects the plants from possible infection from red rust spores produced throughout the season.

## Highlights

*Aroma constituents in tea are dominant during first and second flushes. Methods of manufacture also influence the production of aroma constituents.*

*C.T.C. manufacture produces more theaflavin group of compounds than Orthodox manufacture.*

*C.T.C. manufacture of unwithered leaf produces bright and brisk liquor.*

*High activity of l-phenylalanine ammonia lyase (PAL) in tea shoot may be an index for quality.*

*Estimation of TF for routine analysis is simplified.*

*Cup infusions of Orthodox teas contain a smaller fraction of the soluble constituents, particularly theaflavins and thearubigins than the C.T.C. teas of the same leaf source.*

## PIGMENT PROFILE STUDIES

In addition to characterisation of tea flush quality, pigment profile analysis has been found useful for evaluation of the tea quality as affected by different agro-techniques and processing conditions. During the season, study was taken up in collaboration with Unilever Research, Colworth Laboratory, Unilever Limited, U.K., to look into the distribution of aroma constituents during different flushes of tea and how they reflect on the quality of tea.

Both Orthodox and C.T.C. teas were manufactured throughout the season from light pruned bushes of Clone TV12 and TV17. Pigment profile analyses of the made teas for characterisation of flush quality were carried out at Tocklai. Aroma constituents of the teas were analysed by GLC in the Colworth Laboratory of Unilever Research, U.K. The teas were also evaluated by Tea Tasters for quality and flush characters.

### (i) Flush quality

Pigment profiles of the made teas were compared with tasters evaluation (Table 8.01). Profiles indicated that there was second flush quality only for a short period. The effect of drought was reflected in the profiles during the early part of July which was unusually dry this year. These profiles were irregular and had lower peaks, suggesting lesser quality.

It was observed that in certain cases the method of manufacture of the two clones influenced the manifestation of flush characters. Clone TV17 was found to be superior to Clone TV12 in quality, confirming previous findings.

Pigment profile analysis indicates that Clone TV12 has first flush character till end of June, when Clone TV 17 has a second flush character. In early July, C.T.C. teas indicated second flush in both the clones, but TV

**Table 8.01.** *Pigment profile analysis and Tasters evaluation of Orthodox and C.T.C. teas*

**Clone TV 12**

| Date | Sample | Tasters remark | | Pigment profile indication |
|---|---|---|---|---|
| | | Tocklai | Calcutta | |
| 15.6.78 | Orthodox | Nothing to account for | Touch of 2nd flush | First flush |
| ,, | C.T.C. | ,, | Early 2nd flush | Touch of 1st flush |
| 29.6.78 | Orthodox | ,, | Nothing to account for | Touch of 1st flush |
| ,, | C.T.C. | ,, | ,, | Touch of 1st flush |
| 6.7.78 | Orthodox | Similar to rains | Not descriptive | Irregular |
| ,, | C.T.C. | ,, | 2nd flush | 2nd flush |
| 13.7.78 | Orthodox | Nothing to account for | Light useful cup | Rain affected |
| ,, | C.T.C. | ,, | Inferior to TV 17 of same date | Rain affected |
| 10.8.78 | Orthodox | ,, | No flush character | Rain affected |
| ,, | C.T.C. | ,, | ,, | Slightly affected by rain |
| 7.9.78 | Orthodox | ,, | Nothing to account for | Slightly affected by rain |
| ,, | C.T.C. | ,, | ,, | Slightly affected by rain |
| 5.10.78 | Orthodox | ,, | ,, | Mixture of rains & autumn |
| ,, | C.T.C. | ,, | ,, | Autumnal |
| 8.11.78 | Orthodox | ,, | | Autumnal |
| ,, | C.T.C. | ,, | | Autumnal |

**Clone TV 17**

| Date | Sample | Tasters remark | | Pigment profile indication |
|---|---|---|---|---|
| | | Tocklai | Calcutta | |
| 15.6.78 | Orthodox | Nothing to account for | Touch of 2nd flush | Touch of 2nd flush |
| ,, | C.T.C. | ,, | Early 2nd flush | Touch of 2nd flush |
| 29.6.78 | Orthodox | ,, | Nothing to account for | Touch of 2nd flush |
| ,, | C.T.C. | ,, | ,, | 2nd flush |
| 6.7.78 | Orthodox | Similar to rains | Not descriptive | Rains |
| ,, | C.T.C. | ,, | 2nd flush | 2nd flush |
| 13.7.78 | Orthodox | Touch of quality | Best liquor-colour-some flavours | 2nd flush mixed with rain |
| ,, | C.T.C. | ,, | Touch of 2nd flush | 2nd flush |
| 10.8.78 | Orthodox | Nothing to account for | No flush character | Rain affected |
| ,, | C.T.C. | ,, | ,, | Slightly affected by rain |
| 7.9.78 | Orthodox | ,, | Nothing to account for | Rain affected |
| ,, | C.T.C. | ,, | ,, | Slightly affected by rain |
| 5.10.78 | Orthodox | ,, | ,, | Mixture of rains & autumn |
| ,, | C.T.C. | ,, | ,, | Autumnal |
| 8.11.78 | Orthodox | ,, | — | Autumnal |
| ,, | C.T.C. | ,, | — | Autumnal |

17 clone continued to have second flush till mid-July. "Rains character" was indicated till early September by both these clones. This was followed by a transition period till early October during which the flush characters changed from rains to autumnal. For the rest of the plucking season, autumnal character prevailed for both Orthodox and C.T.C. teas of both clones.

### (ii) Flush quality and aroma profiles

The aroma constituents of the black teas were extracted by steam distillation in Likens Nicholson apparatus and was finally taken in freon 113, concentrated and analysed by GLC. The column was packed with Carbowax 20 M and heated initially to 65°C. The temperature programming was done from 65°C to 200°C increasing it at the rate of 7°C per minute. All GLC traces were comparable since the conditions of aroma extraction and analysis were identical. Peaks identified correspond to eight different aroma constituents and the peak heights (in cm) give the relative concentrations of the aroma profiles. Data on relative concentrations of the different aroma constituents of Clones TV 12 and TV 17, are in Tables 8.02 and 8.03 respectively, along with the flush characteristics as indicated by pigment profile.

**Table 8.02.** *Relative concentrations (peak heights in cm) of aroma constituents in C.T.C. and Orthodox teas of Clone TV 12 with respect to flush characters*

**C.T.C.**

| Aroma components Date | Phenylacetal-dehyde | Linalool | t-linalool oxide | t-2-hexenol | Cis-3-hexenol | t-2-hexenal | n-hexanal | Methyl butanal | Pigment profile indication |
|---|---|---|---|---|---|---|---|---|---|
| 15.6.78 | 20.4 | 7.00 | 4.2 | 2.1 | 1.4 | 58.8 | 12.9 | 58.0 | Touch of 1st flush |
| 29.6.78 | 19.8 | 10.8 | 6.7 | 2.7 | 3.2 | 65.4 | 10.4 | 30.2 | Touch of 1st flush |
| 6.7.78 | 19.8 | 9.7 | 6.9 | 3.2 | 3.8 | 91.2 | 14.5 | 34.0 | 2nd flush |
| 13.7.78 | 23.8 | 26.0 | 16.8 | 3.3 | 4.7 | 65.6 | 16.4 | 52.8 | Rains affected |
| 10.8.78 | 4.9 | 10.5 | 10.3 | -- | -- | 13.0 | 2.8 | -- | Slightly affected by rain |
| 7.9.78 | 8.2 | 7.4 | 1.7 | -- | -- | 14.9 | 4.2 | -- | Slightly affected by rain |
| 5.10.78 | 8.1 | 7.3 | 2.6 | -- | -- | 16.5 | 7.0 | -- | Autumnal |
| 8.11.78 | 8.2 | 22.0 | 4.2 | 1.0 | 1.8 | 42.4 | 8.7 | 10.9 | Autumnal |
| **Orthodox** | | | | | | | | | |
| 6.7.78 | 13.5 | 23.2 | 18.2 | 6.0 | 15.6 | 32.4 | 7.6 | 34.4 | Irregular |
| 13.7.78 | 18.2 | 11.0 | 31.6 | 7.6 | 17.0 | 38.0 | 10.6 | 51.6 | Rain affected |
| 10.8.78 | 8.6 | 9.8 | 15.2 | 1.0 | 2.2 | 5.9 | 3.7 | 21.4 | Rain affected |
| 5.10.78 | 5.2 | 9.3 | 3.2 | -- | 1.1 | 17.0 | 5.6 | -- | Mixture of rains and autumn |
| 8.11.78 | 3.6 | 22.4 | 5.3 | -- | -- | 11.9 | 4.2 | 14.6 | Autumnal |

**Table 8.03.** *Relative concentrations (peak heights in cm) of aroma constituents in C.T.C. and Orthodox teas of Clone TV 17 with respect to flush characters*

**C.T.C.**

| Aroma components Date | Phenylacetal-dehyde | Linalool | t-linalool oxide | t-2-hexenol | Cis-3-hexenol | t-2-hexenal | n-hexanal | Methyl butanal | Pigment profile indication |
|---|---|---|---|---|---|---|---|---|---|
| 15.6.78 | 31.6 | 24.6 | 9.0 | 3.2 | 1.5 | 80.8 | 18.8 | 60.8 | Touch of 2nd flush |
| 29.6.78 | 23.0 | 28.4 | 10.6 | 2.6 | 2.9 | 72.0 | 16.0 | 41.2 | 2nd flush |
| 6.7.78 | 17.8 | 23.2 | 11.4 | 2.9 | 2.8 | 78.4 | 12.9 | 26.8 | 2nd flush |
| 13.7.78 | 28.2 | 61.0 | 11.6 | 2.8 | 2.9 | 18.4 | 15.3 | 59.2 | 2nd flush |
| 10.8.78 | 10.1 | 14.2 | 7.0 | -- | -- | 14.9 | 4.7 | -- | Slightly affected by rain |
| 7.9.78 | 6.5 | 2.7 | 1.3 | -- | -- | 17.1 | 4.6 | -- | Slightly affected by rain |
| 5.10.78 | 7.3 | 15.0 | 2.4 | -- | -- | 17.4 | 5.6 | -- | Autumnal |
| 8.11.78 | 4.5 | 17.5 | 2.8 | -- | -- | 22.4 | 4.2 | 10.8 | Autumnal |
| **Orthodox** | | | | | | | | | |
| 15.6.78 | 21.6 | 67.6 | 16.4 | 8.7 | 9.3 | 28.9 | 9.9 | 58.0 | Touch of 2nd flush |
| 29.6.78 | 19.2 | 48.4 | 14.0 | 3.5 | 8.2 | 20.0 | 8.4 | 47.2 | 2nd flush |
| 6.7.78 | 18.0 | 54.4 | 14.4 | 4.7 | 8.9 | 35.4 | 8.3 | 36.4 | Rains |
| 13.7.78 | 28.0 | 113.6 | 116.8 | 7.0 | 10.2 | 26.4 | 11.0 | 62.4 | 2nd flush mixed with rain |
| 10.8.78 | 5.1 | 16.7 | 16.8 | -- | -- | 3.8 | 1.8 | 16.6 | Rain affected |
| 7.9.78 | 11.9 | 16.6 | 11.3 | -- | -- | 7.7 | 3.3 | -- | Rain affected |
| 5.10.78 | 11.2 | 28.4 | 11.0 | 1.1 | 1.1 | 13.3 | 9.1 | -- | Mixture of rain and autumn |
| 8.11.78 | 5.0 | 26.8 | 5.6 | -- | 1.6 | 16.2 | 7.5 | 17.1 | Autumnal |

These results show, irrespective of the method of manufacture, China hybrid clone (TV17), in general, has a higher concentration of phenylacetaldehyde, linalool, and trans-linalool oxide, while the concentrations of trans-2-hexenol, trans-2-hexenal, n-hexanal and methyl butanal in this clone are similar to those of the Assam clone (TV12). Concentration of Cis-3-hexenol which imparts a fresh green odour is lower in the China hybrid than in the Assam clone.

Another interesting feature was that the same source of leaf behaved differently in the production of aroma constituents when manufactured by Orthodox and C.T.C. methods (Figs 8.01 & 8.02). In both clones, Orthodox process produced more of linalool, trans-linalool oxide, trans-2-hexenol and cis-3-hexenol than in C.T.C. process, while in the latter process trans-2-hexenal, n-hexanal and phenylacetaldehyde were comparatively higher. Methyl butanal concentration was similar in both types of teas. It appears that Orthodox process helps in the development of more aroma components than the C.T.C.

Further, the levels of aroma constituents were generally higher in the first and second flushes than in the rains.

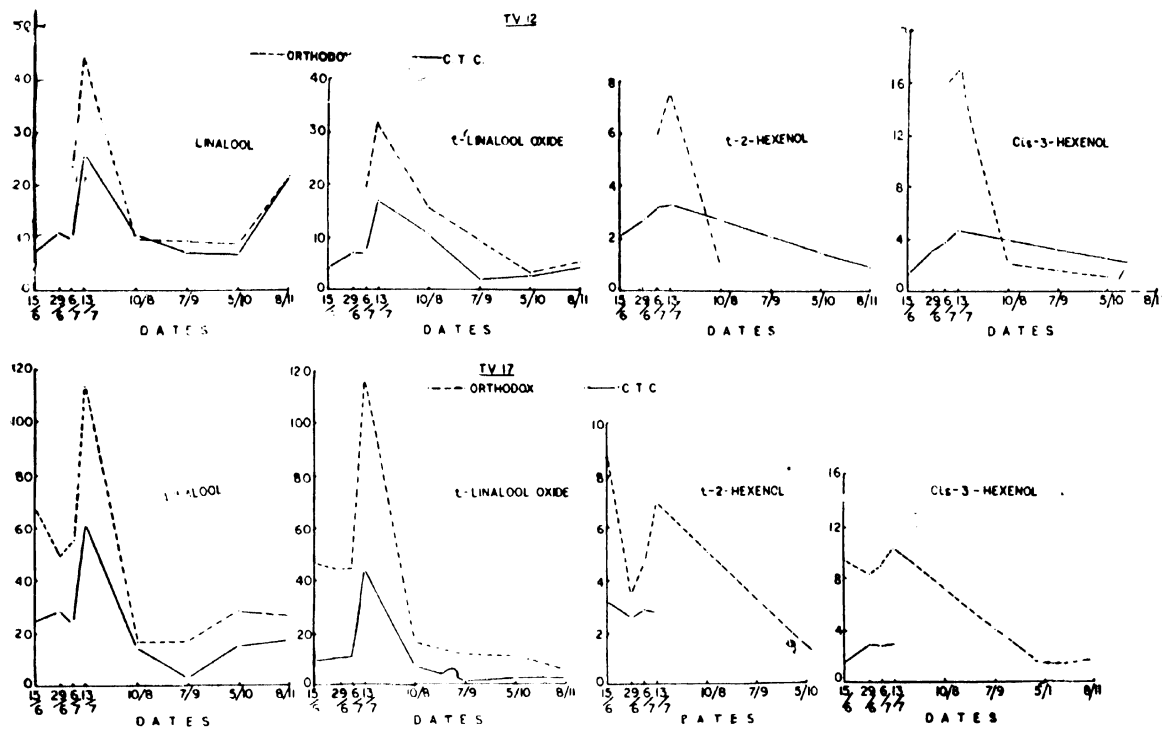



**Fig 8.01 Volatile constituents of Orthodox and C.T.C. teas**

A substantial depression in the concentration of the volatiles was observed during the autumn flush.

Both the tasters detected "quality" in Clone TV 17 on 13th July (Table 8.01). It is seen from Table 8.03 that these samples had higher concentrations of linalool, trans-linalool oxide, phenylacetaldehyde and methyl butanal compared to the earlier and latter samples. The Orthodox teas had very high concentrations of linalool and trans-linalool oxide. It appears that unsaturated alcohols related to geraniol might be contributing more toward aroma which boosted up the quality of tea.

### (iii) Pigment analysis by Unilever Research

Unilever Research also carried out analysis of the Theaflavin (TF) pigments by HPLC. An aqueous extract of the tea was solubilized by mixing with acetone (7:1 approx.) and after centrifugation at 1500 g the supernatant was used in the HPLC. The wave length was set at 380 nm to detect the coloured components eluted from the column by acetone : acetic acid : water mixture. The relative heights of the peaks in all the traces were comparable on a quantitative basis (Table 8.04).

The data show that the C.T.C. process generally produces more coloured components than the Orthodox process. The concentration of pigments in TV17 ifs higher than in TV12. Irrespective of the method o manufacture TV17 has the maximum concentration of TF followed by its gallates, while in Clone TV12, the concentrations are generally in the reverse order.

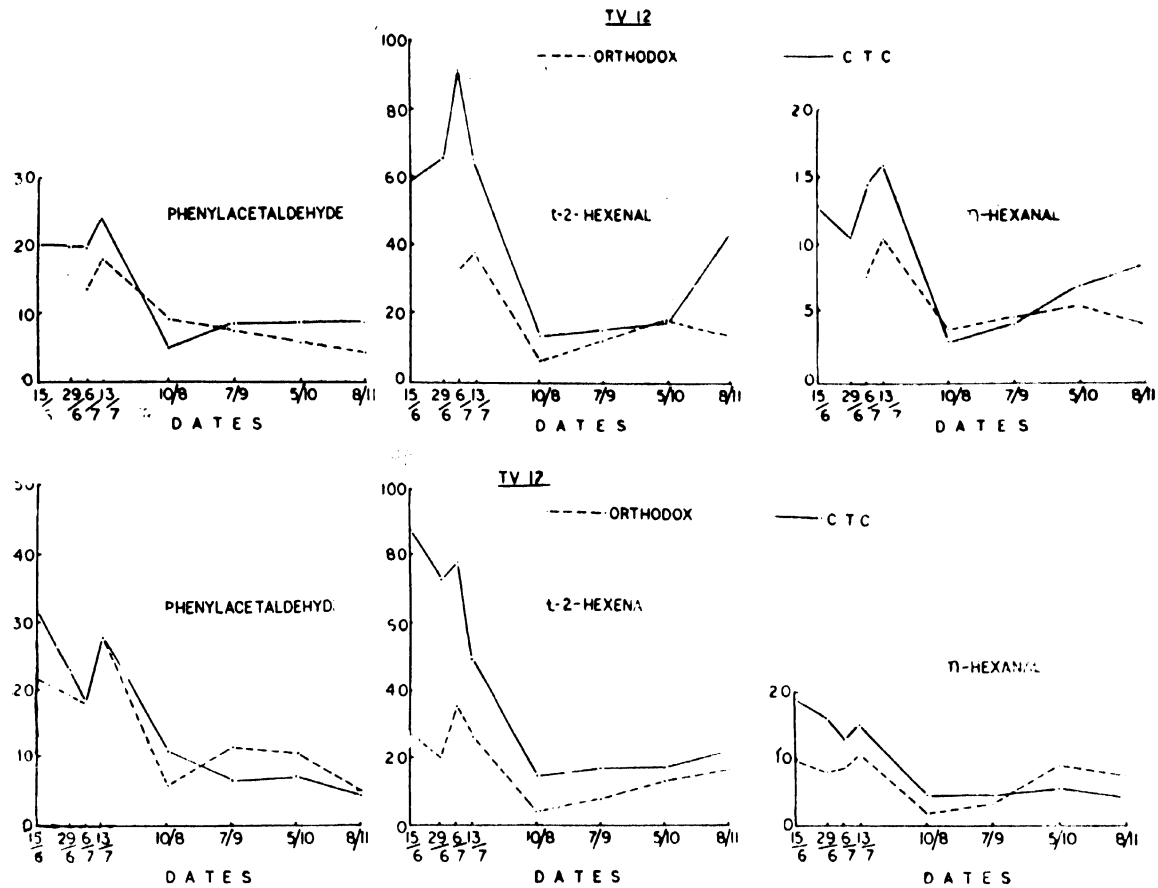



**Fig 8·02 Volatile constituents of C.T.C. and Orthodox teas**

**Table 8.04.** *Relative concentrations (peak heights in mm) of the pigment constituents of Orthodox and C.T.C. teas from Clones TV 12 and TV 17*

| Date of manufacture | TF | | TFG | | TFGG | |
|---|---|---|---|---|---|---|
| | Ortho-dox | C.T.C. | Ortho-dox | C.T.C. | Ortho-dox | C.T.C. |
| **Clone TV 12** | | | | | | |
| 15.6.78 | 86 | 100 | 91 | 124 | 107 | 150 |
| 29.6.78 | 57 | 140 | 63 | 105 | 72 | 89 |
| 6.7.78 | 85 | 120 | 105 | 145 | 126 | Very high |
| 13.7.78 | 61 | 81 | 62 | 101 | 69 | 133 |
| **Clone TV 17** | | | | | | |
| 29.6.78 | 58 | 195 | 56 | 190 | 62 | 188 |
| 6.7.78 | 157 | 220 | 133 | 212 | 122 | 215 |

TF — Theaflavin
TFG — Theaflavin monogallates
TFGG — Theaflavin digallate

## Physical and chemical wither

A preliminary laboratory scale investigation was undertaken to study the chemical changes associated with physical and chemical withers of tea leaf and their effect on quality of made tea. The object of the study was to find out if the usual period of chemical wither can be reduced without any deleterious effect on the overall quality of made tea.

Fresh leaf from Clones TV1 and TV9 were subjected to the following treatments on four occasions during July and August :

1) Artificial physical wither by blowing alternately hot ( 90° - 95°F ) air and air at room temperature during a total withering period of 4 and 8 hours (for chemical wither, designated as CP) .

2) No physical or chemical wither (Fresh leaf).

3) Natural wither for 16 hrs (control sample, designated as N).

After these treatments the respective samples were manufactured by C.T.C. method. Fresh leaf samples were also manufactured without withering. The fresh leaf, withered leaf and the corresponding made teas were analysed chemically and made tea samples were sent to tea tasters for evaluation (Table 8.06).

Chlorophyll content decreased with withering and the total soluble nitrogen showed an increase. The TF content did not change, while slight increase in TR was noticeable between unwithered and withered leaf. The tasters gave almost equal preference to naturally

**Table 8.06.** *Effect of withering on chemical constituents of leaf and corresponding C.T.C. teas and their evaluation by tasters*

| Withering period hr | Leaf: % Moisture | Leaf: % Wither | Leaf: % Chlorophyll (a + b) | Leaf: % Total soluble nitrogen | Made Tea C.T.C.: % TF | Made Tea C.T.C.: % TR | Made Tea C.T.C.: TF/TR | Tasters valuations (Rs/kg): Calcutta | Tasters valuations (Rs/kg): Tocklai |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **Clone TV 9** | | | | | |
| 0 (Fresh leaf) | 78.50 | 96.0 | 0.466 | 1.81 | 1.44 | 11.29 | 0.100 | 12.68 | 6.40 |
| 4 (CP) | 72.02 | 73.8 | 0.409 | 1.80 | 1.40 | 15.84 | 0.090 | 12.20 | 6.50 |
| 8 (CP) | 72.92 | 76.2 | 0.351 | 1.83 | 1.53 | 16.61 | 0.092 | 13.14 | 6.75 |
| 16 (N) | 72.78 | 75.8 | 0.334 | 1.99 | 1.51 | 16.70 | 0.090 | 13.06 | 6.80 |
| | | | | **Clone TV 1** | | | | | |
| 0 (Fresh leaf) | 78.01 | 96.0 | 0.332 | 1.38 | 1.82 | 18.81 | 0.097 | 14.55 | 6.80 |
| 4 (CP) | 71.31 | 73.5 | 0.269 | 1.49 | 1.60 | 19.83 | 0.081 | 15.50 | 6.33 |
| 8 (CP) | 70.99 | 72.7 | 0.202 | 1.51 | 1.63 | 19.67 | 0.083 | 17.84 | 7.25 |
| 16 (N) | 73.17 | 75.6 | 0.201 | 1.80 | 1.66 | 19.69 | 0.084 | 15.21 | 7.17 |

withered and 8 hr artificial withered teas from TV9. More extensive experiments are, however, necessary to arrive at a definite conclusion regarding the period of storage of tea leaf to achieve adequate chemical wither.

It was of interest to note that fresh leaf when manufactured by C.T.C. process produced bright and brisk liquor. This is corroborated by high TF/TR ratio (Table 8.06) which is directly correlated to brightness and briskness.

### L-phenylalanine ammonia lyase

The enzyme, l-phenylalanine ammonia lyase (PAL) is associated with the biosynthesis of catechins which are converted to TF and TR during manufacture. The mechanism of biosynthesis is through deamination of phenylalanine to trans-cinnamic acid which is regarded as the first step in the metabolic sequence. Because of its significance in catechin synthesis, the presence of the enzyme in tea shoot was examined.

Tea shoots were found to be rich in PAL activity. Activity of the enzyme was maximum in the bud but decreased with maturity of the leaf. The activity was the least in the stem portion. It is of interest to note that the distribution pattern of the catechins in shoot components follow the same trend as the activity of the enzyme. This indicated that high PAL activity might be associated with increased production of catechins, and hence, the quality. High PAL activity in tea shoot might, therefore, be considered as one of the indices for made tea quality.

During withering of the leaf, there was considerable loss in the activity of this enzyme.

## DIVERSIFICATION OF PRODUCTS

During the season, instant tea samples were manufactured by different processes in the instant tea pilot plant at Tocklai. These samples were analysed for various chemical constituents in order to evolve a chemical basis for their quality as well as to improve the method of manufacture.

At the initial stages, made tea samples were used for extracting the soluble solids for preparing instant tea. This resulted in poor extraction and produced instant tea of inferior quality. These samples contained very low TF and high TR. It was likely that during the process of hot extraction and subsequent drying of the extract at high temperature, polymerisation increased resulting in low TF and high TR.

Controlled oxidation of the raw material and its subsequent extraction under suitable conditions greatly improved the product, which had well-balanced TF and TR and gave brisk and bright brew. The work on this project is being continued.

## TF ESTIMATION METHOD

The current method of estimation of TF has been simplified; the details will be published in *Two and a Bud.*

### Composition of cup infusion

The total soluble solids in made tea obtained by exhaustive hot water extraction of a good quality tea ranges from 40 to 45 per cent of the dry weight. Compared to taster's 5 minute infusion, such an infusion, although rich in soluble solids, does not have the desired effect on the palate. Exhaustive extraction perhaps brings such substances into the liquors which offset the balance of desirable chemicals found in a cup of tea. Results of examination of the distribution of chemicals extracted in a taster's cup of tea and after exhaustive extraction for 1 hour are shown in Table 8.09.

Only about 85 per cent of the total soluble solids of C.T.C. teas are extracted in a cup. While caffeine and soluble sugar fractions of the solids are almost completely extracted, tannins are extracted from 87 to 90 per cent. Extraction of TF ranges from 90 to 94 per cent. The creaming index of a cup infusion is only 61-77 per cent of that of 1 hr infusion. The higher cream index and tannin contents of 1 hr infusion appear to make it bitter and heavy in the palate.

**Table. 8.09** *Composition of Taster's infusion and 1 hour infusion of C.T.C. teas from Clone TV 17.*

| Chemical Components (% dry wt.) | June manufacture | | | August manufacture | | |
|---|---|---|---|---|---|---|
| | 1 hr infusion | Cup infusion | % Extracted in cup | 1 hr infusion | Cup infusion | % Extracted in cup |
| Soluble solids | 39.17 | 33.54 | 85.6 | 44.28 | 37.54 | 84.8 |
| Tannin | 12.84 | 11.58 | 90.3 | 15.80 | 13.81 | 87.4 |
| Caffeine | 1.92 | 1.88 | 97.9 | 4.59 | 4.46 | 97.2 |
| Soluble sugar | 1.41 | 1.40 | 99.3 | 1.48 | 1.44 | 97.3 |
| TF | 1.80 | 1.62 | 90.0 | 1.62 | 1.52 | 93.8 |
| TR | 19.20 | 16.38 | 85.3 | 20.80 | 17.42 | 83.8 |
| Cream index (per gm) | 157.28 | 95.78 | 60.9 | 66.21 | 50.78 | 76.7 |

The extractibility in C.T.C. and Orthodox teas from the same source of leaf is shown in Table 8.10. Because of the basic difference in Orthodox and C.T.C. teas, their chemical composition also differ as can be seen from these results. The cup infusion of the Orthodox tea contains much less of the soluble chemicals than the C.T.C. tea from the same source of leaf.

**Table. 8.10** *Composition of Taster's infusion and 1 hr infusion of C.T.C. and Orthodox teas from Clone TV 12.*

| Components (% dry wt.) | 1 hr infusion | | Cup infusion | | % Extracted in cup | |
|---|---|---|---|---|---|---|
| | C.T.C. | Ortho-dox | C.T.C. | Ortho-dox | C.T.C. | Ortho-dox |
| Soluble solids | 44.28 | 45.79 | 38.54 | 32.00 | 87.0 | 69.9 |
| Tannin | 15.80 | 16.99 | 13.81 | 11.64 | 87.4 | 68.5 |
| Caffeine | 4.59 | 4.72 | 4.46 | 3.87 | 97.2 | 82.0 |
| TF | 1.62 | 1.24 | 1.52 | 0.78 | 93.8 | 63.0 |
| TR | 20.80 | 16.34 | 17.42 | 11.02 | 83.7 | 67.4 |
| Cream index (per gm) | 66.21 | 47.87 | 50.78 | 39.31 | 76.6 | 82.1 |

## ADVISORY SERVICE

Water samples and detergents received from different Tea Estates were examined for their suitability for use in Tea Factory.

Kay-bee and N-Foss moisture meters of various Tea Estates were standardised and calibrated.

# Tea Tasting

## Highlights

*Time of plucking is a decisive factor in the percentage recovery of made tea from withered leaf. Interim findings show that certain alternative lining materials for plywood tea chests did not taint made teas or had any significant difference in moisture content, chemical constituents etc. compared to conventional aluminium foil lining even three months after storage.*

### RECOVERY PERCENTAGE FROM LEAF PLUCKED AT DIFFERENT TIMES OF THE DAY

In collaboration with the Botany Department, an experiment was carried out to find out the recovery percentage and cup-characters of made tea from leaves plucked at different times of the day. The result shows that percentage recovery increases as plucking is deferred from 07.00 hrs to 14.00 hrs. Percentage recovery was the minimum at 07.00 hrs and maximum at 14.00 hrs. The rate of recovery varied between clones and the time intervals.

Table 9.01 below gives details of the hours of plucking and Taster's evaluation.

**Table 9.01** *Average valuation in Rs/kg of teas plucked at different hours of the day*

| Tasters | TV1 | | | J.T.C.L. CLONES | | |
|---|---|---|---|---|---|---|
| | 07.00 hrs | 11.30 hrs | 14.00 hrs | 07.00 hrs | 11.30 hrs | 14.00 hrs |
| A | 7.81 | 7.12 | 7.00 | 8.00 | 7.78 | 7.71 |
| B | 11.35 | 13.66 | 12.39 | 12.55 | 13.08 | 12.91 |
| C | 13.40 | 13.55 | 13.52 | 13.38 | 13.45 | 13.43 |

There was some variation in the tea tasters' choice. One consistently preferred the 07.00 hrs teas, while the two others preferred 11.30 hrs teas.

### Lining materials for plywood tea chests

Linings of 12 micron Metallised Polyester film, 300 MXXT (Saron coated) and 300 MSAT regenerated cellulose films, the latter two under the brand names 'Trayophane' and 'Kesophane' respectively, were tested along with standard conventional lining in 50 kg plywood tea chests.

The interim findings, based on storage of tea for three months, show that none of these linings imparted any taint or caused any adverse effect on the liqour characteristics of made teas. Moreover, there was no significant difference in the moisture content of teas packed with different lining materials. Teas stored in these lining materials maintained the same characteristics as tea stored in plywood chests having aluminium foil and tissue paper linings. Two of the experiments were started in October and the third in December, and will be continued for a storage period of six months after which details of taster's evaluation, moisture content and biochemical assessment will be published.

### Blending of Jat and Clone

In continuation of the previous findings on mixing of clonal tea (C.T.C.) with jat tea in different proportions (Annual Report 1977-78, P. 67), further observations were made. When 15% to 20% of tea from clones TV 9 and TV 18 of inferior quality were mixed with 80% and 85% tea from a good jat (Betjan), strength of liquor and quality of the overall bulk improved.

A part of this work was carried out in collaboration with Unilever Research, U.K. The object was to measure the colour of tea consistently so that in due course it might be possible to use computer to achieve desirable blends of colour in cup. The work is in progress.

For assessment of cup-to-cup variation of colour, three clones, TV1, TV9 and TV18 were blended singly with Betjan jat in proportions of 100:0, 90:10 and 80:20. The measurements were made with 6.6 g of tea infused for 6 minutes in 250 ml water. Ten millilitres of milk was added and the colour tone was determined in the seventh minute.

There was cup-to-cup variation in colour not only due to variations in blending, but also because of non-uniformity in manufacture and non-reproducible sampling from large bulk. Experiments will be continued by minimising these sources of error to the extent possible.

### Improvement of C.T.C. leaf appearance by split C.T.C. method

In general C.T.C. teas of some clones like TV 1 appear brown, which reduces the value of the made tea. Experiments were carried out at Tocklai miniature factory with the object of changing the leaf appearance of TV1 by split C.T.C. method. The following sequence was adopted.

75% wither (1) Rolling for 20 minutes
(2) First cut C.T.C.
(3) Fermentation 20 minutes
(4) Second cut C.T.C.
(5) 15 minutes fermentation
(6) Dry at inlet temperature of 210° F

The TV 1 teas thus manufactured appeared a little more black. Further experiments are in progress.

**Dual manufacture of jat and clone with different percentage extractions of fines**

In continuation of the previous investigations on dual manufacture with different percentage extractions (Annual Report 1977-78, P. 67), further studies were made on the effect of 10%, 20% and 30% extractions on the cup characters of C.T.C. teas, manufactured from unpruned bushes of jats and clones. The wither obtained was 66% to 68% and the withered leaf was rolled for 30 minutes in a Little Giant Roller.

The extracted fines were processed for making orthodox tea after fermenting for three hours including rolling time. The coarse mal was passed twice through C.T.C. and fermented. The orthodox samples were dried for 55 minutes at an inlet temperature of 190° F and the C.T.C. samples were dried for 30 minutes at the same inlet temperature in the Tocklai miniature factory.

66% wither produced orthodox teas of good make and appearance with fair colour and briskness in cup. At this relatively hard wither of leaf from unpruned bushes, the C.T.C. teas made after extraction of fines did not have fullness in cup and had a little flakey appearance.

**Table 9.02.** *Manufacture and quality assessment of experimental samples*

| Title of Experiment | No. of samples manufactured at: Tocklai | Nagrakata |
|---|---|---|
| Management Practice | 312 | 416 |
| Residue and tainting trials | 90 | — |
| Long term trial of clones | 1500 | 415 |
| Green tea | — | 12 |
| Instant tea | 45 | — |

**Evaluation of commercial products**

'Deepclean', a liquid detergent, supplied by Messrs D.M. Industries (India), Calcutta was tested for washing fermenting room floors and processing machinery in tea factories. The sample of detergent had a pH of 7.0 and was considered suitable for use, provided normal precaution is taken to ensure that the floor is thoroughly washed with clean water to remove possible deposits of the liquid material.

pH of the following detergents were found to be as follows :

| | |
|---|---|
| Dedenol Super N | 7.20 |
| Hedansan liquid detergent | 7.45 |

The maximum permissible limit for a detergent should be between pH of 6.5 and 7.0.

ADVISORY WORKS

(a) **Tasting sessions:** 26 group tasting sessions were arranged by the Area Scientific Committees in different parts of N.E. India. The tasting sessions were followed by discussions on manufacture under different factory conditions. Visits were paid wherever necessary. The planters took keen interest in these sessions and the following discussions.

The Tea Tasters visited 150 factories to advise on manufacturing problems.

(b) **Seminars** : Nine Engineering and Manufacturing Seminars held in N.E. India were attended by the Tea Tasters.

(c) **Tasting** : Number of samples tasted during the year at

| | |
|---|---|
| Tocklai | 18,320. |
| Nagrakata | 22,114. |

# Engineering Research & Development

## Highlights

*One commercial unit of 45 cm Continuous Tea Roller manufactured and installed in an estate is working fully satisfactorily and two more commercial units have been installed in two other estates. The first roll performance of the 37 cm prototype Continuous Tea Roller has also improved considerably, and teas from this machine were generally preferred to conventional teas by Tasters.*

*After some modifications in the design, the B.L.C. Mark II is now giving as well processed leaf as the rotorvane does. Some modifications in the design of the Cutter Attachment were also done for its satisfactory working with rotorvane.*

## CONTINUOUS GREEN LEAF PROCESSING MACHINES

### (a) **Continuous Tea Roller (CTR)**

(i) 45 cm Model : Three commercial units of 45 cm Continuous Tea Roller have been manufactured and installed at Halem T.E., Aidaupukhuri T.E. and Chabua T.E. during the year. The first two were manufactured by M/s Trade & Industry Pvt. Ltd. of Tezpur and the third one by M/s Steelsworth Ltd. of Tinsukia. The machine at Halem T.E. is working regularly from 5th August 1978. After some initial troubles, which were sorted out quickly by correcting the inaccuracies and repositioning some vanes, and when the "running in" period was over the performance of the machine was fully satisfactory both during the first roll as well as during the second roll. The manager in his report on the performance of the machine mentioned that tasters from a broker house who tasted the samples preferred C.T.R. teas to conventional teas in leaf grades and overall standard. For second roll, the manager reported, the capacity was established at 1800 kg/hr and with a higher wither the machine could take as much as 2200 kg/hr. Another noticeable feature reported was that the exposure of stalks is less in the C.T.R. probably because the skin is not peeled off. When the machine was tried for the first roll, the manager reported, the output achieved was only 450 kg/hr and after two passes through the C.T.R. the appearance of the sorted teas compared favourably with that of conventional teas. On checking the 1st roll capacity was found to be 570 kg/hr. In his next report the estate manager reported that the machine is doing an exceptionally good job as a 2nd roll machine.

The machine at Chabua T.E. was installed during the end of the season. After some initial troubles the machine started working satisfactorily but could not be used for long to give any conclusive result during the last season. During the early 1979 season the machine was further checked up and cleared for regular use. The performance is now satisfactory.

The other machine, which is an improved version made by M/s Trade & Industry Pvt. Ltd. with a modified frame incorporating all the improvements done at Halem T.E. was installed at Aidaupukhuri T.E., during March '79 and is running fully satisfactorily from the beginning.

The original 45 cm prototype built at Tocklai was installed at Hunwal factory where it was used for the routine second roll during the first and early second flush period to the full satisfaction of the estate.

Pending the issue of manufacturing licence, permission has been granted for construction of a few more 45 cm Continuous Tea Rollers in view of the demand for this machine from the industry.

(ii) 37 cm model : The 37 cm prototype Continuous Tea Roller was installed in Hunwal factory for further trials and development under commercial conditions particularly with reference to first roll performance. Various modifications to the rotor of the machine during the course of the year resulted in improved performance. As the estate was doing only dual manufacture from the second flush period, this machine was tried out for dual manufacture only. A summary of tasting reports given by Tocklai and Calcutta Tasters is given in tables 10.01 and 10.02.

These results show that the performance of the 37 cm C.T.R. improved continuously throughout the season and finally the 1st fine samples from the C.T.R. were preferred to corresponding conventional samples a higher number of times, while the C.T.C. samples from C.T.R. coarse were preferred to corresponding Roll/C.T.C. samples more or less throughout the year a higher number of times. Work on its further improvement will be continued under Darjeeling Conditions next year.

### (b) **Withered Leaf Preconditioner**

The brass rollers for the withered Leaf Preconditioner were received at the end of the 1978 season and the construction of the machine was completed by the beginning of the next season. Hence no trial of the machine could be taken during the year.

### (c) **Barbora Leaf Conditioner Mark II**

The commercial version of the Barbora Leaf Conditioner Mark II was found to be giving underprocessed leaf. The machine installed at Monabarie T.E. was taken

**Table 10.01.** *Summary of Tocklai Taster's report on 1st fine and C.T.C. Samples from the trial of 37 cm Continuous Tea Roller*

| Month | No of sets of comparative samples. | | No. of CTR. samples preferred or valued at par | | Per cent no. of C.T.R. samples preferred or valued at par | |
|---|---|---|---|---|---|---|
| | 1st fine | C.T.C. | 1st fine | C.T.C. | 1st fine | C.T.C. |
| May | 26 | 26 | 22 | 17 | 84.6 | 65.3 |
| June | 26 | 26 | 11 | 16 | 42.3 | 61.5 |
| July | 40 | 39 | 17 | 20 | 42.5 | 51.- |
| August | 28 | 28 | 13 | 19 | 46.4 | 67.8 |
| Sept. | 16 | 16 | 7 | 11 | 43.7 | 68.7 |
| Oct. | 8 | 12 | 4 | 6 | 50.0 | 50.0 |
| Nov. | 13 | 13 | 7 | 9 | 53.8 | 69.2 |
| Dec. | 5 | 6 | 3 | 4 | 60.0 | 75.0 |

**Table 10.2.** *Summary of Calcutta Taster's report on 1st fine and C.T.C. samples from the trial of 37 cm Continuous Tea Roller*

| Month | No. of sets comparative samples | | No. of C.T.R. samples preferred or valued at par | | Per cent no. of C.T.R. samples preferred or valued at par | |
|---|---|---|---|---|---|---|
| | 1st fine | C.T.C. | 1st fine | C.T.C. | 1st fine | C.T.C. |
| May | 16 | 16 | 6 | 8 | 37.5 | 50.0 |
| June | 26 | 25 | 10 | 10 | 38.4 | 40.0 |
| July | 37 | 36 | 15 | 9 | 40.5 | 25.0 |
| August | 23 | 23 | 14 | 13 | 60.8 | 56.5 |
| Sept. | 13 | 14 | 8 | 7 | 61.5 | 50.0 |
| Oct. | 2 | 2 | 1 | - | 50.0 | |
| Nov. | 3 | 3 | — | — | | |
| Dec. | 5 | 6 | 3 | 3 | 66.0 | 50.0 |

up for improvement. The baffle ring at the discharge end was replaced by a plane ring and the diameter of the pressurising plate was increased. This gave very satisfactory result and now the machine gives as well processed leaf as the rotorvane does. Hence these modifications are made standard features of the machine.

(d) **Cutter Attachment to B.L.C. and Rotorvane**

The new modified Cutter Attachment made of stainless steel is working satisfactorily with B.L.C. in Leesh River T.E. The cut obtained is reported to be similar to the 1st cut C.T.C. But damage was caused to the cutter blades frequently due to presence of metal pieces in the leaf. To avoid this difficulty the manufacturers have been advised to incorporate a shear pin and alarm bell arrangement.

Although the Cutter attachment is working satisfactorily with B.L.C., it had some problems with the rotorvane at Monobarie T.E. due to leaf jamming and excessive heat development. To improve the performance a set of specially designed resistors were fitted to the discharge end of the rotorvane. As a result, the Cutter Attachment worked better without leaf jamming and heat development. Also after this modification Cutter plates with a higher number of blades could be used to give a finer cut. But it was found that although acceptable results were obtained this way the motor was getting overloaded. Hence it has been decided to modify the design further to incorporate baffle ring to facilitate passage of leaf through the Attachment without overloading the motor. Modification drawings and the baffle ring have already been supplied to the estate. The modification work will be carried out by the estate in the next season.

## CONTINUOUS FERMENTING MACHINE

The Continuous Fermenting Machine manufactured by M/s Tea-Ma Consortium under TRA's licence and installed at Cinnamara T.E. was having some troubles. The machine was therefore thoroughly checked up and was reported on. The matter has now been taken up with the manufacturers on the basis of the report for necessary modification and rectification of the defects.

## PLUCKING AID

Efforts to get a light weight d.c. motor and light weight Nickel-Cadmium battery suitable for motorising the plucking aid so far could not produce any result. The battery is available but its cost is prohibitive, while a suitable light weight d.c. motor could not be found yet. Hence attempts are now being made to use an ordinary lead acid battery with a long flexible cable and a d.c. motor of available type, although not quite suitable. A model of motorised plucking aid has been made in this way but for its acceptable performance further improvements are necessary. Work in this direction has been taken up. In the mean time efforts are being made to import two plucking aid machines from Japan, one battery operated and the other a small two-stroke engine operated.

## SEPARATION OF STALKS

Further work has been taken up to try out various ideas to find out an effective principle for this purpose. Models are being constructed for trying out some more ideas.

## WITHERING EQUIPMENT

Work has been started to produce a model of a compact, efficient and continuous withering system.

## CALIBRATION OF MOISTURE METER

Laboratory work for the calibration of the kappa moisture meter for C.T.C. bulk tea, BP, OF and dust has been completed. The data is being analysed by the Statistics Department for developing the calibration equations.

## 45° GROOVE ANGLE C.T.C. CHASER

A tool making firm has been located to manufacture 45° groove angle 8 T.P.I. C.T.C. chasers reported last year for increasing the out put of C.T.C. rollers. The firm, M/s Continental Engineering Co., "Neelkanth", 26 B Camac Street, Calcutta 700016 can now supply such chasers.

## MISCELLANEOUS

**All India Co-ordinated Project**

Some work in the field of development of Tea Machinary have been proposed in collaboration with

amination of such factors as distribution of rainfall, soil type, depth of soil, etc., of the concerned estate.

(iii) Irrigation and drainage requirement suggested in Table 11.01 need to be tested by actual field experiments before large scale programme is adopted.

## Darjeeling

### SURVEY ON FIELD MANAGEMENT AND ENVIRONMENTAL FACTORS AFFECTING THE YIELD OF TEA

This survey was undertaken for the period 1953-'73 on 51 member estates in Darjeeling. The object of this survey with some results was reported in the Tocklai Annual Scientific Reports, 1975-'76, pp. 61-62; 1976-'77, pp. 65-67 and 1977-'78, pp. 74-77. Further, results from the survey during the year are summarised below:

#### (i) Area under different jats of tea (as on 31.12.73)

The distribution of land under different *jats* of tea showed that 80 per cent of the total area were planted with dark leaf type of tea and only 4 per cent with light leaf tea. About 12 per cent were found to be planted with mixed *jat* of tea and the information on the remaining 4 per cent was not available.

#### (ii) Tea area under shade

Out of the total area under tea about 56 per cent area were found to be shaded while 38 per cent were unshaded. Information on the remaining 6 per cent was not available. Further, most (about 42%) of the shaded tea was located upto an elevation 1068 m (3500').

#### (iii) Distribution of area(%) under tea at different elevations

Most (79%) of the Darjeeling tea were planted between an elevation of 610 m (2000') and 1525 m (5000') and only about 8 per cent were upto 610 m (2000') and 6 per cent above 1525 m (5000'). Elevation of the remaining 7 per cent area under tea was not available. Detailed distribution can be seen from Table 11.02.

**Table 11.02.** *Distribution of area (%) under tea at different elevations in 1973*

| Elevation | | % of total |
|---|---|---|
| Metres | Feet | |
| Below 305 | Below 1000 | 4 |
| 305 - 610 | 1000 2000 | 4 |
| 610 915 | 2000 3000 | 17 |
| 915 1220 | 3000 4000 | 33 |
| 1220 1525 | 4000 5000 | 29 |
| Above 1525 | Above 5000 | 6 |
| Unknown | | 7 |

#### (iv) Location of tea at different aspects

Maximum area (about 20%) under tea was at north aspect (Table 11.03) followed by 16 per cent each at east and west, and 13 per cent at south aspect. Only about 30 per cent were at north-east, south-east, south-west and north-west aspects.

**Table 11.03.** *Distribution of area (%) under tea at different aspects in 1973*

| Aspect | % of total |
|---|---|
| North | 20 |
| North-east | 8 |
| East | 16 |
| South-east | 6 |
| South | 13 |
| South-west | 6 |
| West | 16 |
| North-west | 10 |
| Unknown | 5 |

#### (v) Area under tea at different angle of the slope

About 70 per cent of the area under tea was on steep slope (above 30 ) and 30 per cent on gentle slope (below 30 ).

#### (vi) Age group of tea and the corresponding yield

The effect of age on the yielding capacity of tea bushes planted on light and heavy soils was reported earlier (Annual Scientific Report, 1976-'77, p.67). Yield (KMTH) increased steadily upto about 35 years and thereafter, it started declining on both the soil types.

Table 11.04 shows the distribution of area by age group of tea and the corresponding yield for 1973.

**Table 11.04.** *Distribution of area (%) and average annual yield by age group for 1973*
(estimate based on 44 estates)

| Age-group (in years) | Percentage of area during 1973 | Average yield of Made Tea (kg/ha) for 1973 |
|---|---|---|
| 0 7 | 0.8 | 357 |
| 7 11 | 1.4 | 581 |
| 11 15 | 0.6 | 730 |
| 15 20 | 0.7 | 776 |
| 20 25 | 0.9 | 869 |
| 25 30 | 1.0 | 1050 |
| 30 40 | 1.3 | 1177 |
| 40 50 | 2.2 | 1027 |
| 50 60 | 2.9 | 906 |
| 60 80 | 6.2 | 793 |
| Above 80 | 25.5 | 755 |
| Unknown | 56.5 | 717 |

Area under tea upto about 35 years upto which yield was found to increase, was very much negligible as compared to the tea area under declining group. This is a very much alarming situation and therefore, needs immediate amelioration.

### ANALYSIS TECHNIQUES FOR LONG-TERM EXPERIMENTAL DATA

In a simple experiment, yield from each plot is represented by yield = Mean yield + effect of treatment
+ effect of repeat (replication)
+ random error ..... (1)

Treatment effect is reflected in treatment variance. This is measured against random error. If the ratio between treatment and random variance is more than a required 'F' value, then the treatment effect is significant, otherwise the 'null hypothesis' is accepted, i.e., the treatment effects are not different.

In case of perennial crop like tea, the experiments are required to be continued for a long period to find out the performance of treatments when applied on the same bushes over a number of years. After completion of the experiment, combined analysis over the period of experimentation is carried out to find out the overall performance of the treatments. In the usual analysis, the growth effect of the bushes due to correlation in yield between successive years of experimentation creeps in to inflate the random error. As a result, the observed error variance over the cumulative years of analysis of data generally shows increasing trend. From the theoretical point of view, the effect of treatments should be tested against the actual random error but, it is being tested against this increased variance. Due to this reason, systematic growth effect has to be segregated from the random error in order to increase the efficiency of experimentation.

Preliminary studies on the pattern of the observed experimental errors over the period of experimentation were made to find out the nature of correlation over the cumulative years of experimentation for the following three long-term experiments.

(a) Uniformity trial (based on 6 years yield data).

(b) Fertiliser experiment (based on 7 years yield data) and

(c) Different methods of Plucking experiment (base on 4 years yield data).

A Statistical methodology for segregating this increasing observed error variance into two components was developed for the above experiments. One typical result is shown in Fig 11.01.

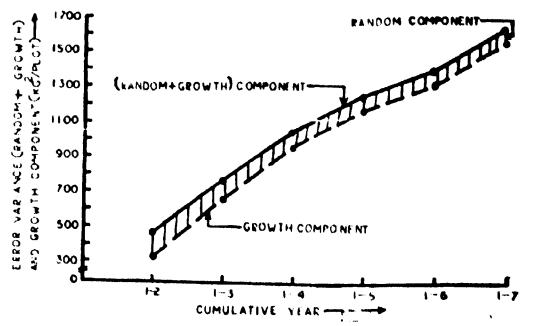



**Fig. 11.01. Observed error variance over cumulative years of experimentation and systematic growth component.**

In this figure, broken line shows the systematic growth effect after segregation of the random component. The difference between the bold and broken lines is the actual random error which has been shown with shade in the figure.

It was found out from this study that observed error variance (Error = E1) generated by a first order autoregressive scheme (Markoff Series) for these experiments, involved growth effect (Eg) and independent random error (Er).

Therefore, on the basis of the above mentioned first order autoregressive scheme, it became possible to segregate the observed error into two parts, *viz.*,

(i) The correlated part (growth component) and

(ii) the random part (experimental error).

The results are presented in Tables 11.05 a, b and c respectively.

Further work is in progress, taking into consideration the age of the tea, length of experimentation and types of experiments, to find out an appropriate statistical method for segregating the observed experimental error and for testing the treatment effects with the appropriate error. This would enable to increase the efficiency and test the treatment effects with the appropriate error.

**Table 11.05.** *Segregation of observed error variance into growth and random components over cumulative years of long-term experimentation with tea*

a. *Uniformity trial experiment (Bokahola T.E.)*
*Date of planting* : *1958*
*Period of experimentation* : *1964-69*

| Cumulative Year → | 1964 | 1964+65 | 1964+65 +66 | 1964+65 +66+67 | 1964+65 +66+67 +68 | 1964+65 +66+67 +68+69 | Range of C.V. (%) |
|---|---|---|---|---|---|---|---|
| Error Variance | | | | | | | |
| Without Segregation (E1) | 64.28 (15.16%) | 157.27 (24.57%) | 293.53 (31.72%) | 352.77 (34.48%) | 454.17 (37.48%) | 535.29 (39.83%) | 15.16 39.83 |
| After segregation — Growth Component (Eg) | 0 | 120.22 (21.48%) | 266.64 (30.23%) | 331.18 (33.41%) | 435.29 (36.70%) | 518.85 (39.21%) | 21.48 39.21 |
| After segregation — Random Component (Er) | 64.28 (15.16%) | 37.05 (11.93%) | 26.89 (9.60%) | 21.59 (8.53%) | 18.88 (7.64%) | 16.44 (6.98%) | 6.98 15.16 |

N.B. : *Figures within brackets indicate C.V.* (%)

**b.** *Fertilizer experiment (As 63)*
*Date of planting : 1931*
*Period of experimentation : 1966-'72*

| Error Variance | Cumulative Year | 1966 | 1966 + 67 | 1966 + 67 + 68 | 1966 + 67 + 68 + 69 | 1966 + 67 + 68 + 69 + 70 | 1966 + 67 + 68 + 69 + 70 + 71 | 1966 + 67 + 68 + 69 + 70 + 71 + 72 | Range of C.V. % |
|---|---|---|---|---|---|---|---|---|---|
| Without Segregation (E1) | | 236.86 (13.30%) | 461.24 (19.21%) | 760.57 (23.76%) | 1040.48 (27.49%) | 1242.40 (29.73%) | 1392.33 (31.82%) | 1628.84 (33.33%) | 13.30 – 33.33 |
| After Segregation | Growth Component (Eg) | 0 | 324.45 (16.11%) | 647.64 (21.93%) | 949.07 (26.25%) | 1158.24 (28.70%) | 1314.06 (30.91%) | 1554.84 (32.56%) | 16.11—32.56 |
| | Random Component (Er) | 236.86 (13.30%) | 136.79 (10.46%) | 112.93 (9.16%) | 91.41 (8.15%) | 84.16 (7.74%) | 78.27 (7.54%) | 74.00 (7.10%) | 7.10 – 13.30 |

N.B. : *Figures within brackets indicate C.V.* (%).

**c.** *Plucking experiment (B 112.1/1)*
*Date of planting : 28.10.1959 to 6.11.1959.*
*Period of experimentation : 1971-'74*

| Error Variance | Cumulative Year ▸ | 1971 | 1971 + 72 | 1971 + 72 + 73 | 1971 + 72 + 73 + 74 | Range of C.V. (%) |
|---|---|---|---|---|---|---|
| Without Segregation (E1) | | 6.67 (5.29%) | 14.28 (8.28%) | 23.47 (9.63%) | 36.65 (10.59%) | 5.29 – 10.59 |
| After Segregation | Growth Component (Eg) | 0 | 10.03 (6.94%) | 17.98 (8.42%) | 30.43 (10.02%) | 6.94 – 10.02 |
| | Random Component (Er) | 6.67 (5.29%) | 4.25 (4.52%) | 5.49 (4.65%) | 6.22 (4.53%) | 4.52 – 5.29 |

N.B. : *Figures within brackets indicate C.V.* (%)

Theoretical work is also in progress in this connection.

## JOINT RESEARCH PROJECT

Analysis of the NPK response surface data for the year 1977, conducted on 18 sites consisting of 36 experiments covering different agro-climatic regions of North-east India (Annual Scientific Report, 1977-'78, p. 77), was carried out during the year.

The study on soil N, P and K with crop for these experiments also continued during the period.

Methodology for combination of experiments on this study over places and years has been developed and further work to achieve the objectives is in progress.

The study with monthly rainfall data for eight tea estates of Upper Assam and Tocklai supplied by Soils & Meteorology Department continued during the year. The probability of receiving upto a certain quantity of rainfall during cold-weather, pre-monsoon and monsoon periods was found out. Further, probability of receiving above a certain quantity of rainfall during each month for the eight tea estates and Tocklai was also found out.

## STATISTICAL SERVICE FUNCTION

Statistical planning, arrangements of blocking and randomisation for different research projects were carried out for a number of experiments during the period.

In addition to this, method of analyses was determined for a large number of experiments of various projects of the Station including Ph.D.projects of the Biochemistry and Soils & Meteorology Departments, to achieve the objectives of the experiments.

## DATA PROCESSING ON THE UNIT RECORD MACHINES AND ON THE ELECTRONIC COMPUTER

Field and Laboratory experimental records for 1977 and 1978 on computerised proforma poured in practically from all the research departments and from the estates of North-east India. Weekly/monthly/yearly yield and other experimental records for about 450 experiments were checked, punched and verified on the Unit Record Machines at Tocklai. Computations of about 480 statistical analyses were carried out on the Unit Record Machines and on the Electronic Computer at the Assam Oil Company, Digboi and I.I.T., Madras, which included 217 computations for the Ph.D. projects of the Biochemistry and Soils & Meteorology Departments. In this connection, 7 computer programmes were written in FØRTRAN-IV language for the combination of experiments on NPK response surface and for the Ph.D. projects for computations of the same on the electronic computer.

# Agricultural Economics

## Highlights

*A study of variations in crop yield within a given agro-climatic tea district, based on data from 450 TRA member estates, showed the possibility of increasing average yields by concentrating on low yielding estates; the potential was highest in Terai. The data provides useful information to Advisory Officer, to look for the factors responsible for low yields and identify the factors for high yields, as well as to help poorer estates in increasing their productivity. This will also help in formulating the R & D projects for increasing the productivity beyond the existing yield levels.*

*Economic evaluation of control of Thatch grass (Imperata) and Sour grass (Paspalum) weeds under experimental condition indicated that one round of glyphosate application was effective for the control of Imperata and Paspalum weeds followed by two rounds of 2,4-D to control broad leaf weeds. The cost benefit ratio was found 1:12.*

*The economic evaluation of clones and seeds was taken up in three parts (a) clones certified and released by Tocklai for Darjeeling (b) clones TV14 TV22 released for plains (c) long-term experiments of different Tocklai clones conducted at Borbhetta. Under Darjeeling conditions improved clones contributed between Rs. 1197 and 6755 per hectare more than the standard. Surprisingly the higher valuation of quality clones does not compensate the loss in yield in some cases. Various long-term of trials at Tocklai New Area show that the clones TV11, TV17, TV18, TV19, TV20, TV22, & TV23 are better yielding than standard clones. Stocks 397, 449 and 450 are better than Tingamira seed. Long-term experiments at Borbhetta showed that TV4, TV8, TV9, TV10, TV11, TV12, TV13, TV14, TV15 TV16, TV17, TV18, TV19 and stock 450 are better in yield than TV1 which was taken as standard.*

*Economics of weed control on 36 estates for the period 1970 to 77, showed that the average cost of weed control declined from Rs. 606 per ha in 1975 to Rs. 538 per ha in 1977 The extra yield due to weed control increased from 123 kg/ha in 1975 to 274 kg/ha in 1977. The cost benefit ratio was found 1:5 in 1977.*

*The motion and time study in 28 estates of Upper Assam Jorhat circle, N.Bank and Dooars was the basis for an educational film depicting different motions involved in plucking operation and their impact on bush, plucked leaf and plucking efficiency.*

*One techno-economic study of an estate in Darjeeling was completed and three Tea Economics courses were conducted during the period.*

### 1. Variations in yield within each sub-area of TRA member estates for the period 1970-76

Variations in yield in similar agro-climatic conditions reflect the level of management of factors of production in neighbouring estates. Hence yield data from 490

**Table 12.01 (a).** *Yield performance for 1976 Darjeeling & Terai*

| Code | Sub Area | No. of Estates | | | Av. Yield | Yield Ranges- Qtls/ha | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Replied | Above Av. | kg/ha | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | 18+ | 19+ | 20 |
| 01 | Darjeeling Cent. | 7 | 7 | 4 | 675 | | | 1 | 2 | 1 | 1 | 1 | 1 | | | | | | | | | | | |
| 02 | Darjeeling East | 7 | 5 | 2 | 844 | | | | 1 | 1 | | 1 | 1 | | 1 | | | | | | | | | |
| 03 | Darjeeling West | 8 | 4 | 1 | 620 | | | | 2 | 1 | | 1 | | | | | | | | | | | | |
| 04 | Teesta Valley | 7 | 6 | 4 | 790 | | | 1 | | | 1 | 1 | 2 | 1 | | | | | | | | | | |
| 05 | Sonada | 8 | 7 | 3 | 602 | | | 2 | 2 | 2 | 1 | | | | | | | | | | | | | |
| 06 | Rungbong | 8 | 5 | 3 | 754 | | | 1 | | 1 | 1 | 1 | 1 | | | | | | | | | | | |
| 07 | Tingling | 4 | 4 | 2 | 885 | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | |
| 08 | Kurseong | 7 | 6 | 2 | 467 | 2 | 1 | 1 | | | | 1 | | | 1 | | | | | | | | | |
| 09 | Mahanadi | 5 | 3 | 2 | 623 | | | 1 | | | 2 | | | | | | | | | | | | | |
| Total Darjeeling | | 61 | 47 | 23 | 696 | 2 | 1 | 7 | 7 | 6 | 7 | 7 | 6 | 2 | 2 | | | | | | | | | |
| 10 | Terai | 20 | 24 | 9 | 1113 | | | | | | | 2 | 5 | 1 | 3 | | 4 | 2 | 2 | | 1 | 3 | 1 | |

**Table 12.01 (b).** *Yield performance for 1976 Dooars*

| Code | Sub Area | No. of Estates | | | Av. Yield | Yield Ranges Qtls./ha | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Replied | Above Av. | kg/ha | 7+ | 8+ | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | 18+ | 19+ | 20+ | 21+ | 22+ | 23-24 | | |
| 11 | Jainti | 9 | 9 | 3 | 1632 | | | | 1 | | | 2 | 2 | 1 | | | 1 | 1 | 1 | | | | | |
| 12 | Kalchini | 13 | 12 | 4 | 1761 | | | | | | | | 2 | 2 | 3 | 2 | | 2 | | | 1 | | | |
| 13 | Dalgaon | 16 | 15 | 7 | 1614 | | 1 | 1 | | | 1 | | 4 | 1 | 2 | 2 | 1 | 2 | | | 1 | | | |
| 14 | Binaguri | 17 | 16 | 8 | 1733 | 1 | | | | | | 3 | 1 | 1 | 1 | 2 | 1 | 3 | | | 3 | | | |
| 15 | Nagrakata | 12 | 12 | 6 | 1634 | | | | 1 | 1 | | 1 | 2 | 1 | | 3 | | 1 | 1 | | | 1 | | |
| 16 | Chulsa | 13 | 12 | 5 | 1781 | | | | | | | | | 1 | 4 | 2 | 1 | 1 | 2 | | | 1 | | |
| 17 | Dam Dim | 27 | 23 | 9 | 1631 | 1 | | 2 | 1 | 1 | 3 | 2 | 1 | 2 | 3 | | 1 | 3 | | | 1 | 2 | | |
| Total Dooars | | 107 | 99 | 42 | 1684 | 2 | 1 | 3 | 3 | 2 | 4 | 8 | 12 | 9 | 13 | 11 | 5 | 12 | 4 | -- | 6 | 4 | | |

**Table 12.01 (c).** *Yield performance for 1976 — North Bank*

| Code | Sub Area | No. of Estates | | | Av. Yield | Yield Ranges — Qtls./ha | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Replied | Above Av. | kg/ha | less than 9 | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | 18+ | 19+ | 20+ | 21+ | 22+ | 23-24 |
| 18 | N.Lakhimpur | 11 | 7 | 4 | 1646 | | | | | 1 | | 1 | 1 | | 2 | 1 | 1 | | | | |
| 19 | East Boroi | 11 | 11 | 5 | 1666 | | | | 1 | | | 1 | 3 | 2 | 3 | 1 | | | | | |
| 20 | Bishnauth | 10 | 10 | 5 | 1808 | | | | | | | 1 | 3 | | 1 | 2 | 1 | 1 | | | 1 |
| 21 | Tezpore | 23 | 21 | 12 | 1565 | | 1 | 1 | | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 1 | | | | |
| 22 | Borsola | 11 | 5 | 3 | 1300 | | | | 1 | | 1 | 1 | 2 | | | | | | | | |
| 23 | Orang | 7 | 5 | 4 | 1795 | | | | | | | | | 1 | | 2 | 1 | | 1 | | |
| 24 | Mangaldai | 17 | 17 | 9 | 1873 | 1 | 1 | | 1 | | | | 2 | 2 | | 2 | 4 | | 2 | 1 | 1 |
| 25 | Goalpara | 8 | 7 | 3 | 1231 | 1 | | 2 | 1 | 1 | 1 | 1 | | | | | | | | | |
| Total North Bank | | 98 | 83 | 45 | 1623 | 2 | 2 | 3 | 4 | 5 | 3 | 8 | 14 | 8 | 9 | 10 | 8 | 1 | 3 | 1 | 2 |

**Table 12.01 (d).** *Yield performance for 1976 — Upper Assam*

| Code | Sub Area | No. of Estates | | | Av. Yield | Yield Ranges - Qtls/ha | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Replied | Above Av. | kg/ha | 7 | 8 | 8-9 | 13+ | 14+ | 15+ | 16+ | 17+ | 18+ | 19+ | 20+ | 21+ | 22+ | 23+ | 24+ | 25+ | 26+ | 27 | 28 |
| 26 | Doom Dooma A | 11 | 9 | 4 | 1963 | | | | | | | | 1 | 1 | 3 | 2 | 1 | 1 | | | | | | |
| 27 | Doom Dooma B | 8 | 5 | 1 | 1914 | | | | | | | | 1 | 3 | | | | 1 | | | | | | |
| 28 | Doom Dooma C | 10 | 8 | 3 | 1982 | | | | | 1 | | 2 | | | 2 | 2 | | | | | 1 | | | |
| 29 | Doom Dooma D | 8 | 8 | 3 | 1908 | | | | | | 1 | 2 | 1 | 1 | 1 | 1 | | | 1 | | | | | |
| 45 | Tingrai A | 10 | 10 | 5 | 1943 | | | | | 1 | 1 | 1 | | 1 | 2 | 1 | 1 | 2 | | | | | | |
| 46 | Tingrai B | 12 | 9 | 4 | 1826 | | | | 1 | 1 | | 1 | 2 | | 3 | 1 | | | | | | | | |
| 36 | Panitola A | 13 | 10 | 5 | 2019 | | | 1 | | | | | 1 | | 2 | 1 | 3 | 2 | | | | | | |
| 37 | Panitola B | 11 | 8 | 3 | 2179 | | | | 1 | | | | | | 1 | 2 | 1 | 1 | | | 1 | | 1 | |
| 33 | Dibrugarh A | 12 | 9 | 5 | 1889 | | | | | | 1 | 3 | | | 1 | 3 | | 1 | | | | | | |
| 34 | Dibrugarh B | 11 | 9 | 4 | 1908 | | | | | | | 2 | 2 | 1 | 1 | | 1 | 1 | 1 | | | | | |
| 35 | Dibrugarh C | 13 | 7 | 2 | 1997 | | | | 1 | | 1 | | | 2 | 1 | | 1 | | 1 | | | | | |
| 38 | Naharkatya A | 12 | 6 | 3 | 1789 | | | | 1 | | 1 | | 1 | 2 | 1 | | | | | | | | | |
| 39 | Naharkatya B | 14 | 9 | 6 | 1719 | 1 | | | 1 | | 1 | | 2 | 1 | 1 | 1 | | | 1 | | | | | |
| 40 | Moran A | 13 | 10 | 4 | 1634 | | | | 2 | 1 | | 3 | 1 | 2 | | | 1 | | | | | | | |
| 41 | Moran B | 13 | 5 | 3 | 2001 | | | | | | | | 1 | | 1 | 3 | | | | | | | | |
| Total Upper Assam | | 171 | 122 | 55 | 1911 | 1 | 1 | 1 | 7 | 4 | 6 | 14 | 13 | 14 | 20 | 17 | 9 | 9 | 4 | | 2 | | 1 | |

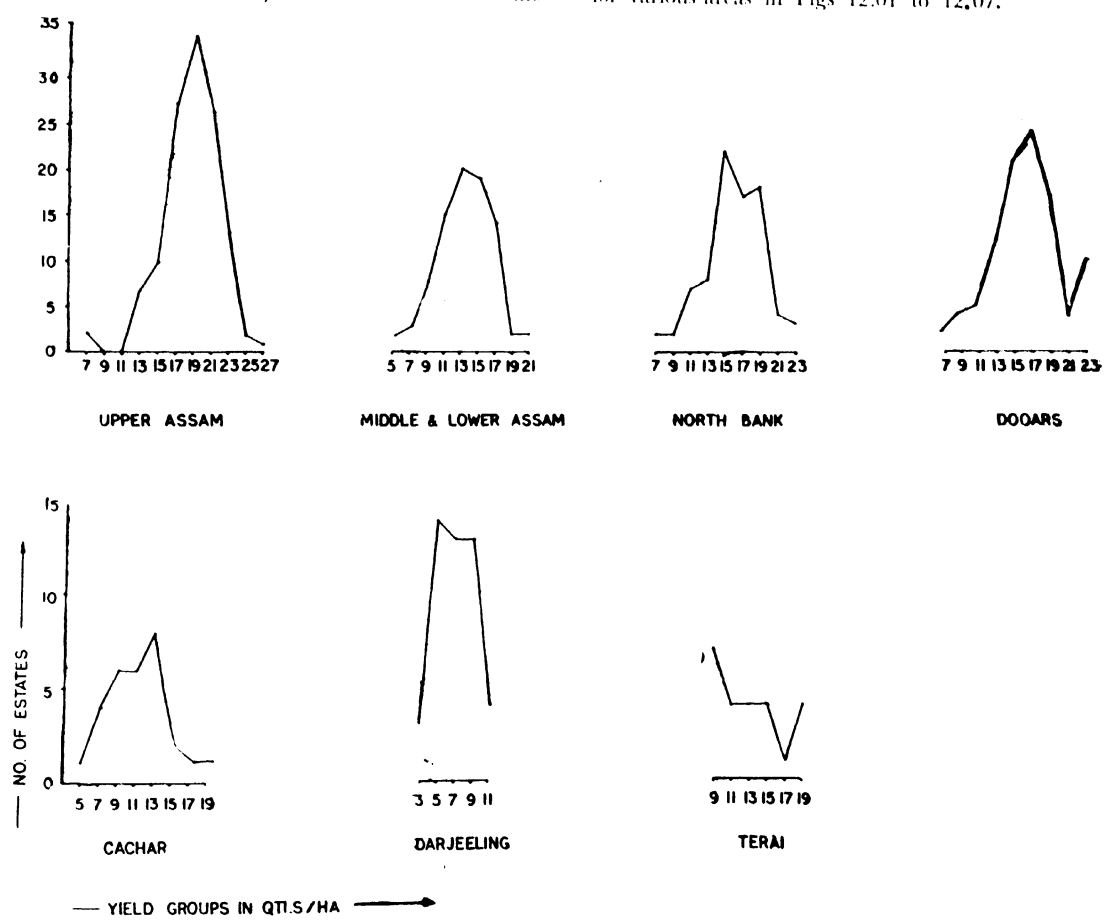
**Table 12.01 (e).** *Yield performance for 1976— Middle & Lower Assam*

| Code | Sub Area | No. of Estates | | | Av. Yield | Yield Ranges - Qtls/ha | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Replied | Above Av. | kg/ha | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | 18+ | 19-20 | 21-23 |
| 30 | Sonari & Nazira A | 13 | 6 | 4 | 1585 | | | | | | | | | 1 | | | 1 | 3 | | | | 1 |
| 31 | Sonari & Nazira B | 13 | 10 | 6 | 1506 | | | | | 1 | | | 1 | 2 | | | 1 | 3 | 1 | | 1 | | |
| 32 | Sonari & Nazira C | 8 | 6 | 2 | 1426 | | | | | | 1 | | | 2 | 1 | | 2 | | | | | | |
| 42 | Jorhat A | 23 | 8 | 3 | 1324 | | | 1 | | | | 1 | 2 | 1 | | 2 | 1 | | | | | | |
| 43 | Jorhat B | 13 | 10 | 4 | 1331 | | | | | | | 1 | 1 | 3 | 2 | 1 | 1 | | | | | | 1 |
| 44 | Jorhat C | 14 | 5 | 3 | 1413 | | | | | 1 | | 1 | | | | | 1 | 1 | 1 | | | | |
| 47 | Golaghat A | 13 | 13 | 8 | 1374 | 1 | 1 | | 1 | | | | | | 2 | 1 | 4 | 1 | 1 | 1 | | | |
| 48 | Golaghat B | 15 | 7 | 2 | 1215 | | | 1 | | | | 3 | 1 | | 1 | | 8 | 1 | | | | | |
| 49 | Golaghat C | 12 | 7 | 4 | 1110 | | | | | 2 | | 1 | 1 | 2 | 1 | 1 | | | | | | | |
| 50 | Nowgong A | 14 | 13 | 6 | 1312 | | | | | | 3 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | | | | | |
| Total Lower Assam | | 138 | 85 | 42 | 1360 | 1 | 1 | 2 | 1 | 4 | 4 | 8 | 7 | 13 | 7 | 7 | 12 | 11 | 3 | 1 | 1 | 2 | |

**Table 12.01 (f).** *Yield performance for 1976 — Cachar*

| Code | Sub Area | No. of Estates | | | Av. Yield kg/ha | Yield Ranges — Qtls./ha | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Re-plied | Above Av. | | 5+ | 6+ | 7+ | 8+ | 9+ | 10+ | 11+ | 12+ | 13+ | 14+ | 15+ | 16+ | 17+ | 18 | 19 |
| 51 | Hailakandy | 15 | 4 | 2 | 1277 | | | | 1 | | | | 1 | 1 | | | | | | |
| 52 | Karimganj & Longoi | 10 | 5 | 3 | 1009 | | | 1 | | 1 | 1 | 1 | | 1 | | | | | | |
| 53 | Happy Valley A | 8 | 1 | 1 | 1498 | | | | | | | | | | 1 | | | | | |
| 54 | Happy Valley B | 11 | 7 | 3 | 1167 | | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | | | | |
| 55 | Chuttabheel | 9 | 6 | 2 | 944 | 1 | 1 | | | 2 | | | | 2 | | | | | | |
| 56 | North Cachar | 10 | 6 | 2 | 1266 | | | 1 | | 1 | 1 | 1 | | 1 | | | | | | |
| | Total Cachar | 63 | 29 | 13 | 1194 | 1 | 1 | 3 | 1 | 5 | 3 | 3 | 2 | 6 | 2 | | | 1 | 1 | |
| 57 | Tripura | 6 | 1 | 1 | 1059 | | | | | | 1 | | | | | | | | | |

TRA member estates were analysed to find out variations in yield and their magnitude within each area where agro-climatic conditions may remain more or less the same. The results are presented in tables 12.01 (a) to 12.01(f) and are shown in frequency distribution graphs for various areas in Figs 12.01 to 12.07.




YIELD PERFORMANCE OF T.R.A. MEMBER ESTATES IN 1976

The bell shaped frequency curves show very clearly at average yields can be increased quickly if the productivity of lower yielding estates is brought up to even erage levels. In case of Terai, the frequency distrition is higher at lower yield levels which shows the ghest potential of increasing average yields.

A wide range of yields within each area indicates the scope of diagonostic study to determine the factors responsible for low yields in the estates in the lower range of productivity levels. Both technical and financial aspects may be responsible for this wide range. This analysis will help our Advisory officers to look

for and identify the factors responsible for very low and high yields of estates within each sub-area and concen-

| YIELD GROUPS QTLS/HA | NUMBER OF ESTATES | | | | | | |
|---|---|---|---|---|---|---|---|
| | UPPER ASSAM | MIDDLE & LOWER ASSAM | NORTH BANK | DOOARS | CACHAR | DARJEE LING | TERAI |
| 2-4 | | | | | | 3 | |
| 4-6 | | 2 | | | 1 | 14 | |
| 6-8 | 2 | 3 | 2 | 2 | 4 | 13 | |
| 8-10 | 4 | 8 | 2 | 4 | 6 | 13 | 7 |
| 10-12 | | 15 | 7 | 5 | 6 | 4 | 4 |
| 12-14 | 7 | 20 | 8 | 12 | 8 | | 4 |
| 14-16 | 10 | 19 | 22 | 21 | 2 | | 4 |
| 16-18 | 27 | 14 | 17 | 24 | 1 | | 1 |
| 18-20 | 34 | 2 | 18 | 17 | 1 | | 4 |
| 20-22 | 26 | 2 | 1 | 4 | | | |
| 22-24 | 13 | | 3 | 10 | | | |
| 24-26 | 2 | | | | | | |
| 26-28 | 1 | | | | | | |
| TOTAL | 122 | 85 | 89 | 99 | 29 | 47 | 24 |

trate on improvements of critical factors for improving the yields. This would also help in formulating the TRA R&D projects in more useful manner to cover the critical factors.

## 2. Economic evaluation of control of imperata and paspalum weeds under experimental conditions in tea

Results of experiments conducted by Agronomy Department on control of *Imperata* and *Paspalum* were evaluated for economic aspects. The cost benefit analysis of the use of various herbicides for control of these weeds were computed for evaluation. The total cost consisted of the cost of herbicide used, cost of sprayer including depreciation and repair and the labour wages.

The results of this were reported by Agronomy Department in their Annual Report (of 1977, Page No. 23) and are shown in table 12.02.

The cost of weed control is persented in table 12.03.

The table clearly indicates that treatment 3, one application of glyphosate for the control of *Imperata* and *Paspalum* followed by two applications of 2,4-D to control broad leaf weeds, is less expensive than all other chemical treatments compared. The net benefit (the difference between the total cost and income) is shown in

**Table 12.02.** *Effect of control of field infestation of Imperata cylindrica and Paspalum conjugatium on the yield of tea in 1977*

| Treatment | No. of applications in the year | Herbicide rate (kg.a.i/ha) per applications | % of weed control | | Yield (kg/ha) | Increase in yield |
|---|---|---|---|---|---|---|
| | | | Imperata cylindrica | Paspalum conjugatum | | |
| 1. No weed control | | | 0 | 0 | 875 | |
| 2. Dalapon | 3 | 3.0 | 60 | 45 | 1152 | 32 |
| 3. Glyphosate | 3 | 0.4 | 95 | 80 | 1577 | 80 |
| 4. Glyphosate, 2,4-D | 1,2 | 0.4,0.8 | 90 | 78 | 1548 | 77 |

**Table 12.03.** *Cost of weed control under different weed control treatments (Rs./hectare)*

| Treatment | No. of rounds | Quantity of formulated herbicide (kg/lt) | Material cost | Equipment cost | Labour cost | Over heads | Total cost |
|---|---|---|---|---|---|---|---|
| 1. Dalapon | 3 | 10.5 kg | 315 | 26 | 90 | 121 | 552 |
| 2. Glyphosate | 3 | 3.0 lt | 720 | 26 | 90 | 234 | 1070 |
| 3. Glyphosate | 1 | 1.0 lt | | | | | |
| 2,4-D | 2 | 2.0 kg | 286 | 26 | 90 | 113 | 515 |

table 12.04. The income is calculated by multiplying the extra yield with unit contribution. For the present study the contribution is taken at Rs. 10 per kg (contribution = Sale price —Variable cost i.e. Rs. 16.00 — Rs. 6.00 —Rs. 10.00).

**Table 12.04.** *Net Benefit due to control of Imperata and Paspalum weeds by various herbicide treatments.*

| Treatments | Increase over 'No weed control' treatment | | Cost of weed control treatments | Net Benefit |
|---|---|---|---|---|
| | Yield kg/ha | Income Rs/ha | Rs/ha | Rs/ha |
| 1. Dalapon | 277 | 2770 | 552 | 2218 |
| 2. Glyphosate | 698 | 6980 | 1070 | 5910 |
| 3. Glyphosate 2,4-D | 673 | 6730 | 515 | 6215 |

The data indicate that glyphosate was more effective for control of *Imperata* and *Paspalum* weeds. However the cost benefit ratio was 1:12, was highest for using one round of glyphosate against these perennial weeds followed by 2,4-D against broad leaf weeds which come up profusely after control of grassy weeds.

## 3. Economic evaluation of clones & seeds —benefit evaluation

The economic evaluation of planting clones and seeds was completed and the results are presented here. In growing a plant from seed or clone, the expenditure incurred would be the same. As such for calculating the benefit in the form of return, only additional yield & additional price (based on taster's report) were taken into account for economic evaluation. Average price of three preceding years (1976 to 1978) was taken into account

for this purpose. In case of Darjeeling, the average price of 1st & 2nd flush as seperate from rain and autumn including back-end crop was taken for calculations for estimating the contribution.

(a) **Clones certified and released by Tocklai for Darjeeling :** Botany Department conducted trials A, B & C for five to seven years at Clonal Proving Station Ging on 25 selected clones since the year 1967, 68 & 69. Tocklai released 12 clones from these trials under interim certification scheme.

Out of the 7 clones under trial A and the 3 clones under trial B, only 2 quality clones under A and 1 quality clone under trial B were released by Tocklai. Out of the 2 clones released under trial C, no quality clone was released.

Under table 12.05, crop distribution (1st & 2nd flush, rain and autumn including back end crop) is given with percentage of share under each period.

**Table 12.05.** *Percentage Crop distribution (with actual yield in kg/ha within brackets) in trials at Clonal Proving Station, Ging, Darjeeling planted in 1967.*

**Trial-A**

| S. No. | Clones | 1st & 2nd flush | Rain crop | Autumn & end crop | Av. Yield (5 yrs) (kg) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | Bannok Burn 157 | 21.1% (180) | 45.8% (391) | 33.1% (282) | (853) |
| 2. | Bannok Burn 777 | 20.4% (131) | 46.9% (302) | 32.7% (210) | (643) Q |
| 3. | Phoob Sering 312 | 19.9% (178) | 49.0% (440) | 31.1% (279) | (897) |
| 4. | Ambari AV 2 | 15.0% (165) | 48.0% (528) | 37.0% (406) | (1099) |
| 5. | Tukdah 145 | 13.5% (90) | 47.7% (319) | 38.8% (259) | ( 668) Q |
| 6. | Tukdah 246 | 10.4% (74) | 46.4% (329) | 43.2% (307) | (710) |
| 7. | Tukdah 253 | 12.1% (118) | 17.6% (451) | 40.0% (379) | (948) |
| 8. | TV1 | 13.8% (37) | 49.2% (133) | 37.0% (101) | (271) |
| 9. | TV7 | 15.1% (19) | 57.8% (72) | 27.1% (31) | (125) |
| *10. | (Stock 378) (Nanda Devi) | 13.5% (99) | 46.4% (339) | 40.1% (293) | (731) |

Q = Quality clones.

**Trial-B Planted in 1968**

| | | | | | |
|---|---|---|---|---|---|
| 1. | TV 14 | 28.4% (350) | 43.5% (537) | 28.1% (347) | (1234) |
| 2. | Bannok Burn 668 | 42.2% (315) | 36.5% (273) | 21.3% (159) | (747) Q |
| 3. | R/R. 4/5 | 37.1% (545) | 42.8% (628) | 20.1% (295) | (1468) |
| 4. | Stock 378 (Nanda Devi) | 35.1% (360) | 43.2% (443) | 21.7% (223) | (1026) |

**Trial-C Planted in 1969**

| S.No. | Clones | 1st & 2nd flush | Rain crop | Autumn & end crop | Av. Yield (7yrs) (kg) |
|---|---|---|---|---|---|
| 1. | 2 | 3 | 4 | 5 | 6 |
| 1. | Tukdah 78 | 27.0% (520) | 48.7% (937) | 24.3% (468) | (1925) |
| 2. | Tukdah 135 | 29.3% (554) | 45.6% (862) | 25.1% (475) | (1891) |
| *3. | Stock 378 (Nanda Devi) | 31.6% (458) | 47.4% (687) | 21.0% (305) | (1450) |

* Control Plot
Q Quality clone

In table 12.06., the yield Index was computed taking the base 100 of the yield of standard (Nanda Devi, Stock 378). It was from this table that the yield of all the clones was higher than those of standard except in case of clones TV1, TV7 & Tukdah 246.

**Table 12.06.** *Yield Index of Clones Released For Darjeeling from trials at clonal Proving Station at Ging*

**Trial-A**

| S.No | Clones | 1st & 2nd flush | Rain Flush | Autumn Flush & end crop | Average |
|---|---|---|---|---|---|
| 1. | Bannok Burn 157 | 181.82 | 115.34 | 96.25 | 116.69 |
| 2. | Bannok Burn 777 | 132.32 | 89.09 | 71.67 | 87.96 Q |
| 3. | Phoob Sering 312 | 179.80 | 129.79 | 95.22 | 122.71 |
| 4. | Ambari AV 2 | 166.67 | 155.75 | 138.57 | 150.34 |
| 5. | Tukdah 145 | 90.91 | 94.10 | 88.40 | 91.38 Q |
| 6. | Tukdah 246 | 71.75 | 97.05 | 104.78 | 97.13 |
| 7. | Tukdah 253 | 119.19 | 133.04 | 129.35 | 129.69 |
| 8. | TV 1 | 37.37 | 39.23 | 34.47 | 37.07 |
| 9. | TV 7 | 19.19 | 21.24 | 11.60 | 17.10 |
| *10. | Nanda Devi (Stock 378) | 100.00 | 100.00 | 100.00 | 100.00 |

**Trial-B**

| | | | | | |
|---|---|---|---|---|---|
| 1. | TV 14 | 97.22 | 121.22 | 155.61 | 120.27 |
| 2. | Bannok Burn 668 | 87.50 | 61.63 | 71.30 | 72.81 Q |
| 3. | R/R. 4/5 | 151.39 | 141.76 | 132.29 | 143.08 |
| *4. | Nanda Devi (Stock 378) | 100.00 | 100.00 | 100.00 | 100.00 |

**Trial-C**

| | | | | | |
|---|---|---|---|---|---|
| 1. | Tukdah 78 | 113.54 | 136.39 | 153.44 | 132.76 |
| 2. | Tukdah 135 | 120.96 | 125.47 | 155.74 | 130.41 |
| *3. | Nanda Devi (Stock 378) | 100.00 | 100.00 | 100.00 | 100.00 |

* = control
Q = Quality clone.

Notes : 1. The yield is converted into Index numbers taking standard as Base under trials A, B & C.

2. Nanda Devi (Stock 378) is the standard which is taken as base.

In table 12.07, the valuation Index is prepared based on the average of the tasters report of Tocklai, Calcutta & London.

**Table 12.07.** *Valuation based on Tasters Report of Clones released for Darjeeling (Standard Stock (Nanda Devi Stock 378) taken as base i.e. 100).*

**Trial-A** 1970

| S.No. | Clones | Tocklai | Calcutta | London | Average. |
|---|---|---|---|---|---|
| 1. | Nanda Devi (Stock 378) | 100.00 | 100.00 | 100.00 | 100.00 |
| 2. | Bannok Burn 157 | 115.57 | 160.01 | 104.69 | 126.76 |
| 3. | Phoob Sering 312 | 134.35 | 107.50 | 100.00 | 113.95 |
| 4. | Tukdah 145 | 143.28 | 130.01 | 103.13 | 125.47 Q |
| 5. | Tukdah 253 | 77.61 | 152.51 | 104.69 | 111.60 |
| 6. | Ambari AV 2 | 85.41 | 135.03 | 112.50 | 110.98 |
| 7. | Bannok Burn 777 | 82.17 | | | 82.17 |
| 8. | Tukdah 246 | 87.13 | | | 87.13 |

**Trial-B**

| | | | | | |
|---|---|---|---|---|---|
| 1. | TV 14 | 101.41 | 134.23 | 115.79 | 117.14 |
| 2. | Bannok Burn 668 | 104.19 | 128.92 | 105.26 | 112.79 Q |
| 3. | R/R. 4/5 | 89.71 | 83.08 | 110.53 | 97.44 |
| 4. | Nanda Devi (Stock 378) | 100.00 | 100.00 | 100.00 | 100.00 |

**Trial-C**

| Sl. No. | Clone | 1972 Tocklai | 1973 Nagrakata | 1974 Nagrakata | 1974 Tocklai | 1975 Nagrakata | 1975 Tocklai I | 1975 Tocklai II | Average |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Tukdah 78 | 104.47 | 104.54 | 104.81 | 106.29 | 116.65 | 101.52 | 105.99 | 106.32 |
| 2. | Tukdah135 | 36.24 | 109.40 | 107.09 | 93.10 | 123.51 | 98.94 | 102.18 | 104.35 |
| 3. | Nanda Devi | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Note 1. Tocklai tasters include Tocklai & Nagrakata

The cost calculations were based on the published Annual Account of tea companies in Darjeeling. In table 12.09, the total valuation realised has been computed for different clones included in trials A, B & C. The yield of different clones for different periods (1st & 2nd flush, rain & autumn) was converted into monetary terms, taking average price realised for different periods.

**Table 12.09.** *Net return based on Yield of different clones for different periods.* Total price based on yield converted into monetary terms taking for realised for different periods.

**Trial-A**

| S. No. | Clones | 1st & 2nd flush (Rs) | Rain Flush (Rs) | Autumn flush & end crop (Rs) | Total (Rs) |
|---|---|---|---|---|---|
| 1. | Bannok Burn 157 | 3292.20 | 4285.36 | 2388.54 | 9,966.10 |
| 2. | Bannok Burn 777 | 2395.99 | 3309.92 | 1778.90 | 7,484.61 Q |
| 3. | Phoob sering 312 | 3255.62 | 4822.40 | 2363.13 | 10,441.15 |
| 4. | Ambari AV 2 | 3017.85 | 5786.88 | 3438.82 | 12,243.55 |
| 5. | Tukdah 145 | 1646.10 | 3496.24 | 2193.73 | 7,336.07 Q |
| 6. | Tukdah 246 | 1353.46 | 3605.84 | 2600.29 | 7,559.59 |
| 7. | Tukdah 253 | 2158.22 | 4942.96 | 3210.13 | 10,311.31 |
| 8. | TV 1 | 676.73 | 1457.68 | 855.47 | 2,989.88 |
| 9. | TV 7 | 377.51 | 789.12 | 287.98 | 1,454.61 |
| 10. | Nanda Devi | 1810.71 | 3715.44 | 2481.71 | 8,007.86 |

For computing returns the average three years price 1976 to 78 in Calcutta auctions for Darjeeling tea was taken into computation. This is shown in table 12.08.

**Table 12.08.** *Average price of Darjeeling tea in Calcutta auctions (1976 to 78)*

| | Average | 1978 | 1977 | 1976 |
|---|---|---|---|---|
| Upto 2nd Flush | 26.69 | 27.40 | 31.72 | 20.95 |
| Rain | 19.36 | 18.18 | 23.88 | 16.02 |
| Autumn | 16.87 | 16.04 | 18.05 | 16.51 |
| | 22.47 | 22.08 | 26.67 | 18.65 |

Cost of Sales – Rs. 21/-
Fixed + Variable costs are :
60% + 40% – 12.60 + 8.40 = 21/-

**Contribution**

26.69 - 8.40 = 18.29 ( 1st & 2nd flush )
19.36 - 8.40 = 10.96 (Rain)
16.87 - 8.40 = 8.47 (Autumn)
22.47 - 8.40 = 14.07 (Total Average)

**Trial-B**

| S. No. | Clones | 1st & 2nd flush (Rs) | Rain Flush (Rs) | Autumn flush & end crop (Rs) | Total (Rs) |
|---|---|---|---|---|---|
| 1. | TV 14 | 6401.50 | 5885.52 | 2939.09 | 15,226.11 |
| 2. | Bannok Burn 668 | 5761.35 | 2992.08 | 1346.73 | 10,100.16 Q |
| 3. | R/R. 4/5 | 9968.05 | 6882.88 | 2498.65 | 19,349.58 |
| 4. | Nanda Devi | 6584.40 | 4855.28 | 1888.81 | 13,328.49 |

**Trial-C**

| | | | | | |
|---|---|---|---|---|---|
| 1. | Tukdah 78 | 9510.80 | 10269.52 | 3963.96 | 23,744.28 |
| 2. | Tukdah 135 | 10132.66 | 9447.52 | 4023.25 | 23,603.43 |
| 3. | Nanda Devi | 8376.82 | 7529.52 | 2583.35 | 18,489.69 |

Q Quality clone.

Note:- 1. The average yield of clones in Trials A, B & C is converted in monetary terms taking the three year (1976,77 & 78) average contribution for 1st & 2nd flush combined, rain and autumn flush & end crop.

In table 12.10., the net benefit has been computed for all the clones. Under column 3, the total price is given, under column 4, the tasters valuation in terms of the percentage of the standard seed stock Nanda Devi is stated and the net benefit is given under column 5. The comparative benefits of different clones over standard variety had been worked out and given under column 6.

**Table 12.10.** *Comparative Benefit Rs/ha from Darjeeling Clones*

**Trial-A**

| S. No. | Clones | Returns based on prices (col. 6 of tab. 12.9) | Valuation Index of varieties (col. 6 of tab. 12.7) | Realisation Av. return x value index | Difference from standard |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1. | Nanda Devi (Stock 378) | 8007.86 | 100.00 | 8007.86 | |
| 2. | Bannok Burn 157 | 9966.10 | 126.76 | 12632.90 | +4625.04 |
| 3. | Phoob Sering 312 | 10441.15 | 113.95 | 11813.99 | +3806.13 |
| 4. | Tukdah 145 | 7336.07 | 125.47 | 9204.48 | +1196.62 Q |
| 5. | Tukdah 253 | 10311.31 | 111.60 | 11507.08 | +3499.22 |
| 6. | Ambari AV 2 | 12243.55 | 110.98 | 13588.39 | +5580.53 |
| 7. | Bannok Burn 777 | 7484.61 | 82.17 | 6150.10 | −1857.76 Q |
| 8. | Tukdah 246 | 7559.59 | 87.13 | 6586.67 | −1421.19 |

**Trial-B**

| | | | | | |
|---|---|---|---|---|---|
| 1. | Nanda Devi | 13328.49 | 100.00 | 13328.49 | |
| 2. | TV 14 | 15226.11 | 117.14 | 17835.87 | +4507.38 |
| 3. | R.R. 45 | 19349.58 | 97.14 | 18851.23 | +5525.74 |
| 4. | Bannok Burn 668 | 10100.16 | 112.79 | 11391.97 | −1936.52 Q |

**Trial-C**

| | | | | | |
|---|---|---|---|---|---|
| 1. | Nanda Devi (Stock 378) | 13489.69 | 100.00 | 13489.69 | |
| 2. | Tukdah 78 | 23744.28 | 106.32 | 25244.92 | +6755.23 |
| 3. | Tukdah 135 | 23603.43 | 104.35 | 24630.18 | +6140.49 |

**Notes :**
1. Net benefit is calculated taking average yield for the trial, valuation of the tasters and the contribution.
2. The clones encircled (Q) are quality clones released for Darjeeling area.
3. Nanda Devi (stock 378) is taken as base for all three trials A, B & C.

In trial A, 5 clones contributed benefit between Rs. 1196.62 to Rs. 5580.53, under trial B, the clones contributed benefit between Rs. 4507.38 to Rs. 5525.74 and under trial C, the benefit contributed was 6140.49 to 6755.25 per ha over standard seed Nanda Devi 378. Tukdah 246 and Bannok Burn 668 & 777 did not contribute and were found inferior to Nanda Devi 378 the standard seed. Ofcourse, one standard clone and two quality clones were released because of their appearance and tip characters. It was manily due to strong demand of the Darjeeling planters that these clones were released.

Darjeeling has got 6 standard, 2 yield & 1 quality clones for extension and replantation. The average yield of these clone is much higher than the average yield of Darjeeling i.e. about 700 kg. The adoption of these clones for extension & replantation will be the major contributory factor to increase the overall yield of Darjeeling and save the industry from facing disaster.

**) Benefit Evaluation of Clones & Biclonal rogenies :** Various long term trials on different ones andbiclonal progenies were conducted at Borhetta and Tocklai new area by the Botany Department. Different varieties were used as standard in different trials and observations on yield performance as well as taster's assessment of the clones and stocks were compared with their respective standards.

The net benefit of the clones and progenies were presented in table 12.11. The benefit is calculated by multiplying the average yield figures of the clones with the contribution. Here the contribution is taken at Rs. 10 - for each variety as the cost of production and price for all of them are taken as the same for this calculation.

Price for clonal tea — Rs. 16 -
Fixed (50%) and variable (50%) cost = Rs. 12/-
Contribution = Rs. 16 - Rs. 6.00 = Rs. 10.00

**Table 12.11.** *Comparative Gain from clones in long-term trial at Borbhetta and Tocklai Divisions.*

**Trial-A.** *Area 50 H Borbhetta, Planted, 1957*

| Clones | Average yield | Benefit (Yield x contribution | Taster's Valuation | Net Benefit | Difference from standard |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| TV 14 | 907 | 9,070 | 102.05 | 9,206 | +1206 |
| TV 16 | 673 | 6,730 | 94.82 | 6,331 | 1669 |
| TV 17 | 825 | 8,250 | 98.48 | 8,100 | + 50 |
| *TV 1 | 805 | 8,050 | 100.00 | 8,050 | 0 |

**Trial-B.** *Area, New Botanical Area, Planted, 1963*

| | | | | | |
|---|---|---|---|---|---|
| TV 18 | 1,712 | 17,120 | 91.70 | 15,699 | + 349 |
| TV 19 | 1,693 | 16,930 | 97.51 | 16,508 | + 1158 |
| TV 9 | 1,626 | 16,260 | 96.55 | 15,699 | + 349 |
| *TV 16 | 1,535 | 15,350 | 100.00 | 15,350 | 0 |

* Standard

**Trial-C.** *New Area, Tocklai Planted, 1970-71*

| | | | | | |
|---|---|---|---|---|---|
| TV 17 | 2,011 | 20,110 | 104.10 | 20,996 | 1965 |
| *TV 1 | 2,296 | 22,960 | 100.00 | 22,960 | 0 |
| TV 14 | 3,320 | 33,200 | | | |
| TV 19 | 4,945 | 19,450 | | | |
| TV 20 | 2,677 | 26,770 | | | |
| *TV 1 | 2,688 | 26,880 | | | |
| TV 21 | 1,853 | 18,530 | 113.38 | 21,009 | 1991 |
| TV 22 | 2,860 | 28,600 | 109.37 | 31,266 | +8266 |
| TV 23 | 2,657 | 26,570 | 105.57 | 28,050 | +5050 |
| *TV 18 | 2,300 | 23,000 | 100.00 | 23,000 | 0 |

**Trial-C.** *Area New Area, Planted 1970*

| | | | | | |
|---|---|---|---|---|---|
| Stock 397 | 2,681 | 26,810 | 95.94 | 19,965 | +2465 |
| Stock 449 | 2,133 | 21,330 | 88.51 | 18,879 | +1379 |
| Stock 450 | 2,160 | 21,600 | 95.67 | 20,881 | +3381 |
| Polyclonal 203 | 1,775 | 17,750 | 98.45 | 17,475 | 25 |
| *Tingamira | 17,503 | 17,500 | 100.00 | 17,500 | 0 |

* Standard

In column 4, the taster's valuation index is given for all clones along with the standard as the base (100). The net benefit of each clone is calculated on the basis of their contribution and taster's valuation and are presented in column 6, the difference of each clone from the respective standard in the form of net benefit is given.

It is observed from table 12.07 (trial-A) that TV 14 and TV 17 were more profitable to grow than the standard TV1 while TV16 was definitely a losing proposition.

Table 12.07 (Trial-B) reflected that all the three clones TV18, TV19 and TV9 were better than standard TV16.

Table 12.07 (Trial-C) showed that returns from quality clone TV17 was much below the standard TV1, TV 22 and TV 23, were found more profitable to grow while TV 21 which had the highest valuation for its quality, was for less profitable in comparison to TV 18. No taster's results were available for the clone TV 14, TV 19 and TV 20.

The results in respect of biclonal progenies are given in table 12.07 (Trial-D). Stock 397, 398 and 400 were better yielding and far more profitable than the standard Tingamira while stock 203 was found slightly inferior to the standard.

(c) **Benefit Evaluation of Clones—experiments conducted by Agronomy Deptt. at Borbhetta (Ref. Agronomy Deptt. Annual Report 1972-73 to 77-78) :** Clones TV1 to TV19 107/2 and stock 450 were planted during the period September, 1966 to June, 1971 at a spacing of 120 cm × 90 cm with 9259 plants per hectare. Clones TV1 to TV14 and Betjan were planted between September, 1966 and April 1967 where as TV15 to TV19, 107/2 and Stock 450 were planted between September 1967 to June 1971.

For the present benefit evaluation TV1 was taken as standard and all the other clones, 107/2 Stock 450 and Betjan were evaluated against it for benefit calculations.

The average yield of the clones TV1 to TV14 and Betjan was based on first seven years production and TV15 to TV19, 107/2 average was based on four years yield. The yield is converted into an index on the basis of standard used, and is summarised in table 12.12.

It is noticeable that the later released clones have been giving higher yields on attaining the age of 5 or 6 years only than the earlier clones which by that time had attained the age of 10/11 years.

The benefit evaluation is based on the contribution being taken as Rs. 10 per kg i.e. on the sale price of Rs. 16 less variable cost of Rs. 6 (Total Cost Rs. 12.00 - Fixed Cost Rs. 6.00 = Rs. 6.00 variable cost) per kilo. This is based on Annual Accounts of a large number of companies in N.E. India.

The net benefit is given in table 12.13.

**Table 12.12.** *Average yield of clones & seeds*

| Clones | Year of Planting | 1976 (L.P.) | 1977 (U.P.) | Average in the form of Index |
|---|---|---|---|---|
| TV 1 | September, 1966 | 1653 | 1960 | 100.00 |
| TV 2 | September, 1966 | 1360 | 2009 | 93.25 |
| TV 4 | Do | 1719 | 2435 | 114.97 |
| TV 6 | 1966/67 | 1463 | 1740 | 88.65 |
| TV 7 | September, 1966 | 1669 | 2013 | 101.91 |
| TV 8 | Do | 1594 | 2440 | 111.65 |
| TV 9 | Do | 1748 | 2270 | 111.21 |
| TV10 | Do | 1876 | 2943 | 133.38 |
| TV11 | Do | 1855 | 2629 | 124.11 |
| TV12 | Do | 1739 | 2654 | 121.59 |
| TV13 | Do | 1855 | 2223 | 112.87 |
| TV14 | Do | 1890 | 2703 | 127.12 |
| TV15 | September, 1967-1970 | 1680 | 2431 | 113.78 |
| TV16 | September, 1966/December, 1970 | 1914 | 2410 | 119.96 |
| TV17 | July, 1967/September, 1968 | 1859 | 3028 | 135.26 |
| TV18 | September, 1969/March,1970 | 1903 | 2716 | 127.84 |
| TV19 | Sept. '69, Dec. '70 & March '71 | 2231 | 2614 | 134.10 |
| 107/2 | Dec. '70, March '71, Nov. '71 | 1717 | 2489 | 116.41 |
| St.450 | March '67, July '67, June '71 | 1686 | 2357 | 111.90 |
| Betjan | April, '67 | 1590 | 2296 | 107.59 |

**Table 12.13** *Contribution towards fixed costs & profitability. Net Benefit of different clones & Betjan seed at Borbhetta*

*Benefit of clones @ Rs. 10/- per kg*

| Clones | Net Benefit (Rs) | Clones | Net Benefit (Rs) |
|---|---|---|---|
| TV 1 | 16,880* | TV 13 | 16,480 |
| TV 2 | 13,920 | TV 14 | 20,570 |
| TV 4 | 18,420 | TV 15 | 18,700 |
| TV 6 | 13,700 | TV 16 | 20,109 |
| TV 7 | 16,620 | TV 17 | 21,730 |
| TV 8 | 16,930 | TV 18 | 20,900 |
| TV 9 | 18,210 | TV 19 | 22,350 |
| TV 10 | 19,990 | 107/2 | 19,380 |
| TV 11 | 19,340 | Stock 450 | 18,430 |
| TV 12 | 18,090 | Betjan | 16,620 |

* Standard

## 4. Economic evaluation of weed control in N.E. India.

A proforma in Economics of Weed Control was sent to 325 TRA member estates in July, 1978. Only 43 estates responded to out proforma and sent us full or partial information. Darjeeling estates did not supply the data regarding cost of weed control. From South Bank, North Bank and Dooars , 36 estates supplied the data.

It is evident from the Table 12.14. that major area is covered under full chemical weed control. A small portion is covered under the partial chemical weed control and the rest under manual weed control. The plains of Assam mainly adopted chemical weed control measures in 1977. In Darjeeling, major area was covered under manual weed control. Fig 12.08 shows that area under chemical weed control has increased much during the later years of 70's.

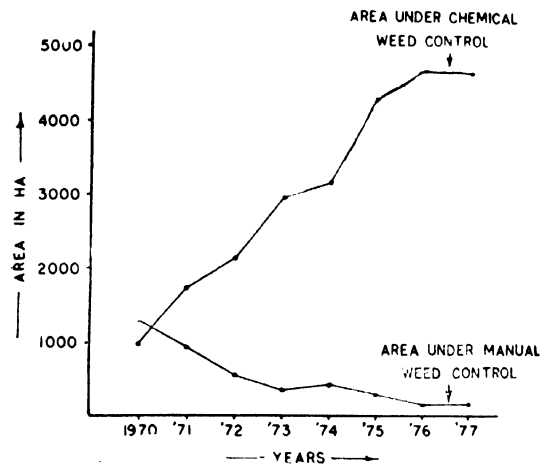



**Fig 12.98. Area covered by chemieal & manual weed control measures during the period 1970-77 on responding estates.**

**Table 12.14.** *Area under chemical and manual weed control in 1977 in 36 responding estates*

| Region | Full chemical | | Partial chemical | | Manual | | Total |
|---|---|---|---|---|---|---|---|
| | ha | % | ha | % | ha | % | ha |
| Dooars | 4338 | 82 | 391 | 7 | 586 | 11 | 5315 |
| N.Bank | 3738 | 95 | 12 | 1 | 160 | 4 | 3910 |
| S.Bank | 4295 | 72 | 205 | 4 | 1458 | 24 | 5958 |
| Darjeeling | 389 | 22 | 155 | 9 | 1205 | 69 | 1749 |
| Total | 12760 | 75 | 763 | 5 | 3409 | 20 | 16932 |

Data collected from 36 estates covering 252 sections regarding weed control measures for the period 1970 to 1977 are presented below in the graph. It shows very clearly that area under chemical control has vastly increased during the later 70's. Evidently chemical weed control has become increasingly popular. Interestingly, the total area under weed control by both manual & chemical methods was much lower in the early years and become much higher in the later years. This reflects the adoption of chemical weed control on all new teas extensions & replantations on the reporting estates.

The cost of chemical weed control is given below for the period of 1975 to 1977. The cost is calculated from 252 sectional sheets of 36 estates of the plains of Assam (S. Bank and N. Bank) and Dooars. The cost of chemical weed control ranges between Rs. 500/- to Rs. 600/- per hectare. The details of the cost analysis are given below :

**Table 12.15.** *Cost of weed control—1975 to 1977 (Per hectare)*

| Year | Cost of manual operations | Cost of herbicide | Cost of stores | Cost of spraying | Total cost |
|---|---|---|---|---|---|
| 1975 | 290 | 207 | 19 | 90 | 606 |
| 1976 | 200 | 216 | 20 | 90 | 526 |
| 1977 | 190 | 222 | 26 | 100 | 538 |

Subjective assessment was made of the gain due to adoption of weed control, by formal discussions with the managers of 16 estates in the plains of N.E. India. The data are given in table 12.16.

**Table 12.16.** *Benefit from chemical weed control in 16 estates of the plains of N.E. India*

| | South Bank | | | North Bank | | | Dooars | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Average yield kg/ha | Average increase kg/ha | % increase | Average yield kg/ha | Average increase kg/ha | % increase | Average yield kg/ha | Average increase kg/ha | % increase | Average yield kg/ha | Average increase kg/ha | Cost based on col. 6 of tab. 12. 15. Rs. | Benefit @ Rs.10 per kg Rs. |
| 1975 | 1321 | 146 | 11.05 | 1680 | 104 | 6.19 | 1579 | 108 | 6.84 | 1500 | 123 | 606 | 1230 |
| 1976 | 1435 | 222 | 15.47 | 1735 | 89 | 5.13 | 1591 | 140 | 8.80 | 1600 | 144 | 526 | 1440 |
| 1977 | 1509 | 244 | 16.17 | 1932 | 320 | 16.56 | 1697 | 199 | 11.73 | 1713 | 274 | 538 | 2740 |

Taking average contribution @ Rs. 10 per kg, 123 kg, 144 kg and 274 kg increase in yield would contribute an additional income of Rs. 1230, Rs. 1440 and Rs. 2740 per hectare and the net benefit per hectare was Rs. 724, Rs. 914 and Rs. 2204 per hectare in 1975, 1976 and 1977 respectively. The ratio of cost and benefit was 1:2.2 in 1975, 1:2.7 in 1976 and 1:5.1 in 1977. This compares with cost benefit in Borbhetta experiment reported earlier, being 1:12 for glyphosate + 2,4-D.

## 5. Motion & Time Study

28 gardens in Assam and Dooars were selected for plucking study during 1978-79. The gardens were located—9 in Upper Assam, 7 in Jorhat Circle, 5 in North Bank and 7 in Dooars. The time plucking observations were taken during the period July to September, 1978 under the supervision of Tocklai Research Assistants and Research Fellow. The data are under analysis and the final result is expected by September, 1979. The motion observations were taken by Cost Advisor and Estate Manager and a film was shot at Borbhetta in November, 1978. The film depicting different motions, correct as well as wrong, and its impact on bush, plucked leaf and plucking efficiency, is being released shortly. Efforts are being made to take up ergonomic study on plucking to correlate various biomedical factors affecting the crop & the pluckers with the plucking efficiency.

### 6. Techno-Economic study

The department undertook a Techno-Economic Study of one estate in Darjeeling. The Agricultural Economist and Cost Advisor with Advisory Officer, Darjeeling visited the estate twice to collect necessary data and consultations regarding future development programmes in the field and factory. The interim report of the study was submitted to the company Directors.

### 7. Tea Economic Courses

The department conducted three courses on Tea Economics during 1978-79, of three days duration each, in October 1978 with 193 planters participating in the courses. The first course was inaugurated by Mr. B.C. Biyani, President, Jayshree Tea & Industries Ltd, New Delhi, the second course was inaugurated by Mr. Prafulla Goradia, Managing Director, Duncan Agro-Industries Ltd., Calcutta and the third course was inaugurated by Dr. S. P. S. Pruthi, Management Consultant, Bombay and former Professor, Indian Institute of Management, Ahmedabad. The first lecture on Profit Planning was given by the Guest Speakers in all three courses. The other seven lectures were delivered by Tocklai faculty. Tocklai faculty consisted of Dr. N.K. Jain, Director, Mr. N.S. Venkatakrishnan, Cost Advisor, and Dr. R. C. Awasthi, Agricultural Economist.

# Instant Tea Project

## Highlights

*The instant tea project at Tocklai is engaged in upscaling the laboratory process developed by Calcutta University for manufacturing soluble tea from green leaves. Various Engineering and Chemical parameters are being studied. Studies so far indicate that as in case of black tea a proper balance of theaflavin (TF) and thearubigins (TR) and caffeine is necessary to get instant tea of acceptable quality.*

A bench-scale process had been developed and patented by Calcutta University for manufacturing instant tea. The Tea Board sponsored a pilot plant project at Tocklai towards the end of 1974 to scale up this process. Completely new facilities had to be built up at Tocklai. A separate building was constructed, and the equipment procured from indigenous sources, completed the installation in the first quarter of 1977.

### THE PROCESS INVOLVED

The process for making Instant Tea from green leaves involves withering, commuting the withered leaves, aerial oxidation (fermentation), extraction of soluble solids, filtration and drying. Several patents exists on foreign technology but the product is not found acceptable to quality conscious palate of tea drinkers which is the main objective of this indigenous patent. The commercial feasibility of the process will depend mainly on

i) the extent of soluble solids extracted;

ii) economics of energy utilisation in processing and drying; and

iii) optimisation of the quality of the product.

### EXPERIMENTAL RESULTS

During the year 62 experiments were conducted using green leaves as raw materials. The process adopted was similar to that of black tea manufacture upto fermentation stage. Extraction of soluble solids by hot water was followed by Spray Drying of the brew to get the dry powdered soluble solids. The intermediate step for cold water soluble product, was chilling and centrifugation to remove precipitates. For extraction, batch type extractors with agitator were used. The product obtained was analysed chemically and organoleptically in collaboration with the Biochemistry and the Tea Tasting Departments respectively, and a correlation was sought to be established between the chemical constituents and the Taster's observations. The extent of extractability of soluble solids from the tea leaves is again limited by the quality of the end product. It is our general experience that a longer period of extraction always gives bitter products. As such, optimisation of the extraction is necessary vis-a-vis the quality of the end product and the economics

**Table 14.01.** *Chemical and organoleptic evaluation of soluble tea manufactured from green leaves by Bat'a extraction & spray drying*

| Mfg. Date | Source | % Caffeine | % TF* | % TR* | TF/TR | pH value | Taster's Remarks |
|---|---|---|---|---|---|---|---|
| 8/6/78 | Bulk | 7.1 | 0.643 | 16.90 | 0.38 | – | Brown in colour. |
| 6/7/78 | TV 18 | 9.28 | 0.612 | 9.35 | 0.654 | – | Fair colour, but lacking strength and briskness. |
| 7/7/78 | TV 18 | 7.5 | 0.85 | 10.4 | 0.817 | – | Fair colour, strength and briskness. |
| 12/7/78 | Bulk | 10.07 | 0.98 | 10.76 | 0.91 | 4.95 | Fair colour, strength and little briskness. |
| 13/7/78 | TV 16 | 6.99 | 0.71 | 8.05 | 0.919 | – | Fair colour, strength and little briskness. |

| Mfg. Date | Source | % Caffeine | % TF* | % TR* | TF/TR | pH value | Taster's Remarks |
|---|---|---|---|---|---|---|---|
| 20/7/78 | TV 18 | 10.59 | 1.03 | 10.01 | 1.025 | 4.9 | Fairly good colour with some strength & briskness. |
| 21/7/78 | TV 16 | 10.70 | 1.02 | 11.71 | 0.87 | 6.0 | Good colour, fairly good strength and some briskness. |
| 24/8/78 | TV 18 | 10.7 | 0.87 | 8.90 | 0.876 | 5.5 | Fairly good colour with some briskness. |
| 31/8/78 | | 8.37 | 0.4 | 18.0 | 0.022 | | Dull and plain. |
| 19/9/78 | Bulk | 7.82 | 0.96 | 11.53 | 0.832 | 4.7 | Fairly good colour with a little briskness. |
| 9/11/78 | TV 18 | 8.48 | 1.01 | 9.45 | 1.068 | 5.7 | Quite brisk colour of this liquor resembles close to medium quality CTC liquor. |
| 10/11/78 | Mixed Clones TV 18 & 16. | 8.0 | 0.75 | 10.5 | 0.714 | 6.3 | Fair colour with some briskness. |

* Values based on Black Tea.

of the process. It is well known that the soluble solids in tea are constituted mainly by the theaflavins (TF), thearubigins (TR) and caffeine. A proper balance of these chemicals must be maintained to get a product of acceptable quality.

Although the results were inconclusive and more experiments are required, some trends of dependance of quality of Instant Tea on the TF/TR ratio were noticed. The results presented in Table 14.01 show the analysis of some of the products.

It is to be noted that in the absence of any standard procedures for chemical and organoleptic evaluation of instant tea, the analytical methods used for black tea were adopted for our product.

Table 14.01 shows that whenever TF/TR ratio is higher, the quality of tea is also superior. This indicates that if TF/TR ratio is controlled to the range used for black tea, better liquor characteristics may be obtained. Some of the samples during the second flush produced quality hot soluble instant tea, which according to Tea Taster, was not distinguishable from the liquors of orthodox tea manufactured concurrently from the same green leaf. The product was also tasted by several professionals and was favourably commented upon by them. Unfortunately its "keeping quality" is yet to reach a desired level.

## Equipment

The following items of equipment are being used in this project.

1. Withering trough
2. Pizey roller
3. CTC machine
4. Batch Extractors (Paddle type mixers)
5. Continuous extractors.
6. Refrigeration unit
7. Demineraliser
8. Centrifuge (Bowl type)
9. Spray drier
10. Packing unit.

Thus the project has at present almost all the necessary equipment except for those required for concentration and aroma recovery. The Spray drier has been giving some trouble from time to time. The temperature controller of the air heating unit of the spray drier went out of order at the beginning itself. The high pressure pump used for atomisation also was not giving the required pressure resulting thereby in the formation of larger particles which could not be dried to the desired level. It was observed that the wet particles formed a layer on the inner wall of the drying chamber and also in the inner wall of the duct of the cyclone. This was due to incomplete evaporation which might have been due to poorer atomisation or due to inadequate surface area for drying. The exact reasons for this, however, could not be ascertained as the heat exchanger of the air-heating unit went out of order towards the end of November and no drying has been possible since. The equipment is under repair and experimentation on extraction continues.

## Personnel

Sponsorer : Chairman, Tea Board.
Convenor : Dr. K.K. Mitra, Director (Research) Tea Board.
Project consultant : Dr. M.M. Chakraborty, Dept. of Applied Chemistry, Calcutta University.

The other members of the staff are :

Project Director : Dr. N.K. Jain, Director, Tocklai Experimental Station.
Project Engineer : (i) M.N. Gogoi.
(ii) Vacant.

The other members of the staff include three plant operators, one clerk and seven helpers including the chowkidar. Of these, the second post of Project Engineer has been lying vacant since March, 1977 and two of the plant operators have resigned during the year 1978-79.

# Investigation on Chemistry of Tea at Sheffield University

## INTRODUCTION

On the recommendation of Engledow Commission of enquiry, 1935-36, the London Scientific Advisory Committee of Indian Tea Association (London) was formed and a plan and programme were drawn up to investigate the chemistry of made tea in London. With the appointment of Dr. E.A.H. Roberts in 1937, chemical investigation on the chemistry of tea began in Tocklai as well as in London's Butler's Wharf Laboratory. In 1952 Dr. Roberts resigned from Tocklai to assume control of the Indian Tea Association's chemical laboratory in London. Again the second Engledow Commission of 1953-54 recommended joint plan and programme of work on the chemistry of tea by Tocklai Laboratory and chemical Laboratory, London. From 1956 to 1963 the report on the work of chemical Laboratory was published in Tocklai Annual Scientific Reports. But, due to sad demise of Dr. Roberts in 1962 the research on tea chemistry was transferred to the Department of chemistry of Sheffield University under Professor Ollis.

The Sheffield group concentrated on isolation, purification and detailed study on the chemical and physical properties for the structural investigations of polyphenol compounds with special reference to theaflavin and thearubigin compounds of tea. Subsequent study upto 1975 related to model tea manufacture using tea components with enzymes and chemicals. Chemical investigations of green leaf and black tea extractives were also carried out with special reference to thearubigin fractions.

This report summarises the work done at Sheffield University between 1963 and 1976 by students and collagues of Dr. Ollis, D. Sant, A.G. Brown, E. Haslam, R.D. Haworth, V.C. Vora and A. Holmes. We are grateful to Prof. Ollis and his group for conducting these studies: to Sheffield University authorities for providing the facilities; acknowledge with thanks the guidance of Sir Frank Engledow FRS CMG, and members of the London Scientific Committee of the TRA and the assistance rendered by the London Scientific Committee Chairman and secretariat. With this, a chapter of international scientific collaboration comes to a close.

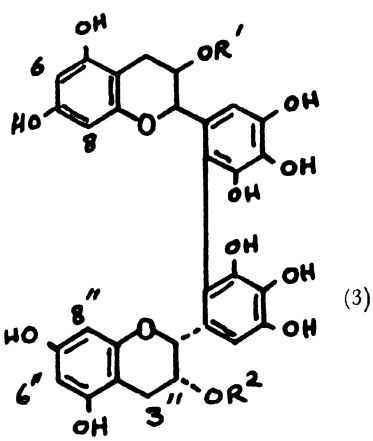
It was proposed in 1976 to continue the research project on the chemistry and biochemistry of black tea in Central Drug Research Institute (CDRI), Lucknow, India under the supervision of Dr. V.C. Vora and Dr. S.P. Popli. Dr. P.K. Mahanta, Assistant Biochemist was appointed by Tocklai in 1978 to carry on the work.

### (a) Study with Model Fermentation systems

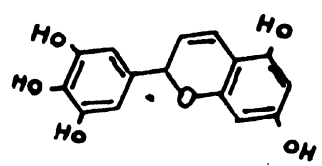
Many groups of workers have studied this aspect of tea chemistry using either acetone washed green leaf powder as the enzyme source or crude soluble tea enzyme preparation and studied the reactions by two dimensional paper chromatography. However, use of column chromatography furnished pure compounds earlier known or unknown and also proved the identity of other compounds.

Both soluble tea enzyme and acetone washed enzyme preparations were made according to the known methods. The substrate used were single polyphenols. Some mixed substrate reactions were also tried. The time allowed was longer as compared to natural one, so as to allow the formation of high molecular weight species (thearubigins).

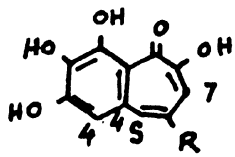
De-esterification of gallated species was the comm on reaction encountered. Formation of bisflavanols (3) occurred in the systems containing epigallocatechin gallate (21) or epigallocatechin (20). Theaflavic acid (8), its isomer (10) and gallate ester (11) were recognised in systems containing catechin (16) and gallic acid, epicatechin (14) and gallic acid and epicatechin gallate (21) and gallic acid. Theaflavin (22) was produced in




(3)

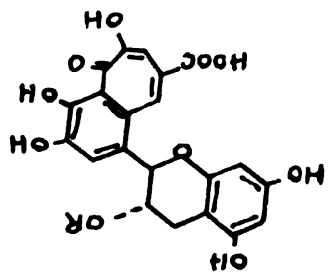



(4) Tricetinidin antioxidant of (--) epigallocatechin

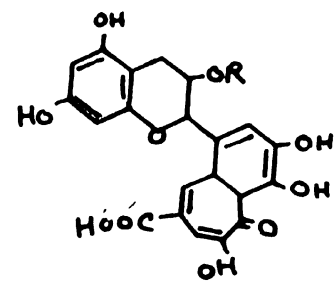


(6) R=H Purpurogallin

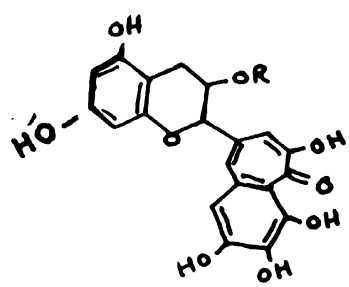
(7) R=CocH ,, -6-Carboxylic Acid



(8) R=H theaflavic acid
(9) R= ,, gallate



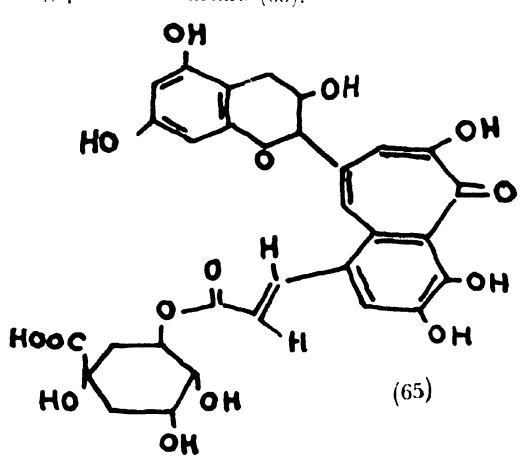
(10) R=H Epitheaflavic acid
(11) R= gallate



(12) R=H Pyrogallin
(13) R=galleyl

systems containing epicatechin (14) and epigallocatechin (20). Oxidation of gallic acid to purpurogallin-6-carboxylic acid (7) was also observed. This showed that decarboxylation took place during this reaction.

In order to study the origination of thearubigin, theaflavin (22), querectin and theaflavin-3, 3'-digallate were incubated separately with enzyme powder but no reaction occured except in the latter where only decarboxylation was observed, thus showing that theaflavins alone do not contribute to the formation of thearubigins. A similar reaction of epigallocatechin and chlorogenic acid (50) yielded Bisflavanol (3) and a red pigment having probable structure (65).



(65)

Incubation of catechin (16) yielded a major yellow product which on the paper chromatogram showed a yellow streak, showing the polymarization of catechin. However comparison of the IR spectrum of the original compounds and reaction product showed great differences. Epicatechin (14) also underwent a similar transformation. Similarly oxidation of epicatechin gallate (15) gave an orange product (60) showing thearubigin characteristics. On the other hand oxidation of catechin (16) and epicatechin gallate (15) yielded a compound having structure (59). Thearubigin type products obtained from different substrates separately such as pyrogallol, gallic acid, catechin, epicatechin, epigallocatechin, epicatechin gallate, epigallocatechin gallate, catechin and gallic acid and epicatechin and epigallocatechin, when subjected to acid hydrolysis did not show the formation of anthocynidins thus ruling out the presence of any proanthocyanidin linkages.

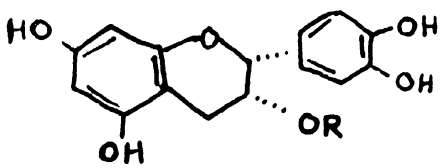
Oxidation of epicatechin only yielded the thearubigin type material, identified as proanthocyanidin dimer (54) thus showing that thearubigin type compounds can be obtained from all tea flavanols and other polyphenols such as gallic acid or purpurogallin-6 carboxylic acid and (7). However flavanols and theaflavins did not afford the thearubigins.

Isolation of low amount of anthocyanidins from the hydrolysis of the black tea thearubigins shows that proanthocyanidin linkages present in thearubigin frame

work may originate from the incorporation of proanthocyanidin molecules in thearubigin, which are in turn present in green leaf.

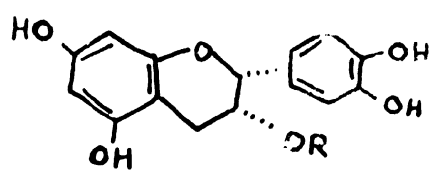
(b) **Synthesis of theaflavins and flavanotropolenes**

Pure (14), (15), (16), (17), (18) and (20) were isolated from natural sources and stored at 0°C. Purpurogallin 6-carboxylic acid (7) was prepared from pyrogallol and gallic acid. Simple 1'-2'-dihydroxy-3-4-benzotropolone (30) and its 6-carboxylic acid (31) were prepared by the oxidation of catechol and pyrogallol or catechol and gallic acid Oxidation of (+) catechin (16) or (−) epicatechin (14) separately with gallic acid afforded (8) or (9) respectively identical with the authentic samples. The oxidising agent used was a mixture of potassium



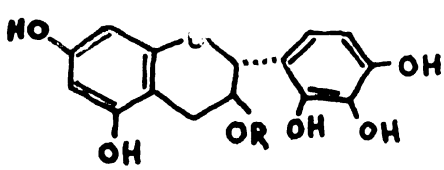
(14) R = H (−) epicatechin

( 5) R = galloyl gallate



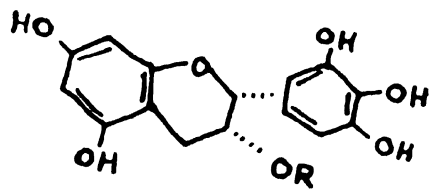
(16) R = H (+) Catechin

(17) R = galloyl (+) Catechin gallate



(18) R = H(+) gallocatechin

(19) R = galloyl; gallate estor

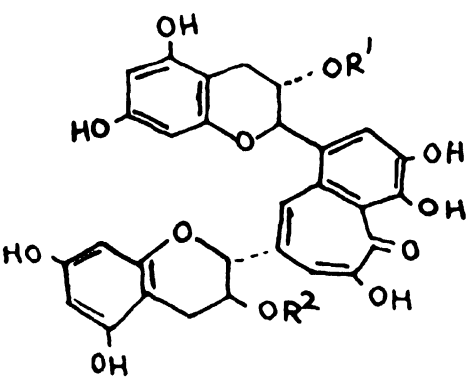


(20) R = H ( ) epigallocatechin

(21) R = galloyl, gallate ester

ferricyanide and sodium bicarbonate. The following four possible theaflavin isomers were synthesised by the oxidation of the flavan-3-ols found in green tea leaf.

Combination (22), (26), (27) and (30) were prepared by the oxidative coupling of (i) (14) and (20); (ii) (14) and (18) : (iii) (16) and (20); and (iv) (16) and (18).

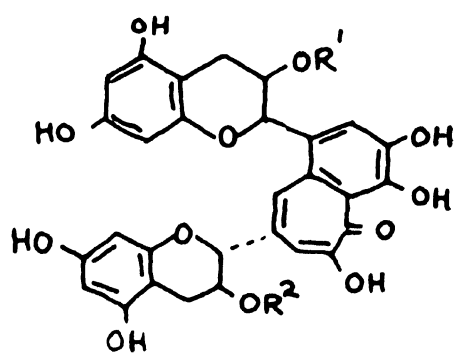


(22) Theaflavin $R_1 = R_2 = H$

(23) Theaflavin-3'-gallate,

(24) Theaflavin-3-gallate.

(25) Theaflavin-3,3 digallate

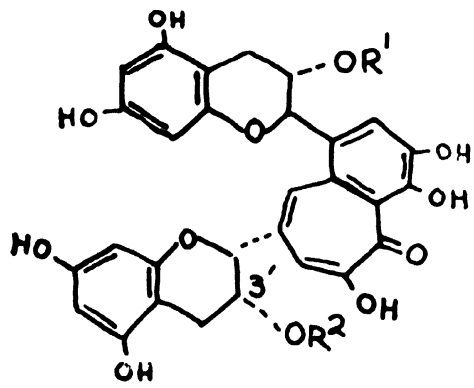


(26) Isotheaflavin $R_1 = R_2 = H$

(31) Isotheaflavin-3'-gallate

(32) Isotheaflavin-3-gallate

(33) Isotheaflavin 3, 3' digallate)



(27) Neotheaflavin $R_1=R_2=H$

(34) Neotheaflavin-3-gallate

(35) Neotheaflavin-3-gallate

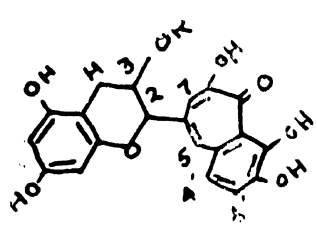
(36) Neotheaflavin-3-3′-digallate

These isomers involved the configurational changes at the C-2, C-3 and C-2′, C-3′ positions of the molecule. The gallate esters were prepared by taking respective gallate precursors.

Compound (30) and its gallate esters have not yet been isolated from the black tea. Also the gallate ester of (26) and (27) have not been reported from black tea.

Methylation of the theaflavins yielded methyl ether while acetylation afforded their acetate. All these compounds were assigned their structures on the basis of IR, UV and NMR data alongwith their appearance in paper chromatography.

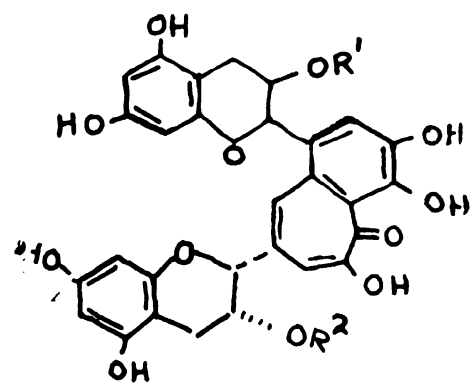
Besides various other flavanotroplones (40), named as categallin, pyrogallin (12) its gallate ester (13) were prepared by the coupled oxidation of catechol and epigallocatechin (20), pyrogallol and (20) and pyrogallol and (21) respectively.



(40) R=H, categallin

(41) R=galloyl, categallin-3-gallate

Oxidation of epicatechin gallate (15) and catechol afforded a product yielded (42) arising from a new novel mode of coupling. Similarly oxidation of (21) and catechol yielded two products. The minor one assigned structure (43) while the major one was assigned structure (41) arising from the usual coupling.

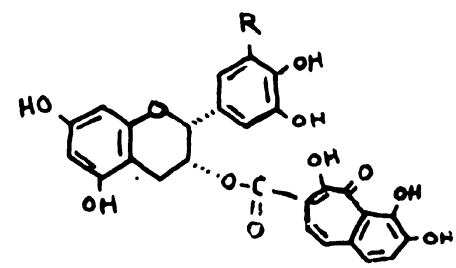


(30) Isoneotheaflavin $R'=R^2=H$

(37) Isoneotheaflavin-3′-gallate

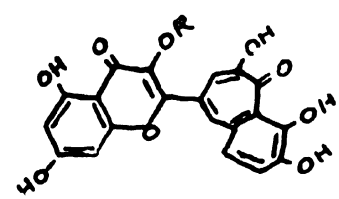
(38) Isoneotheaflavin-3-gallate

(39) Isoneotheaflavin 3, 3′-digallate



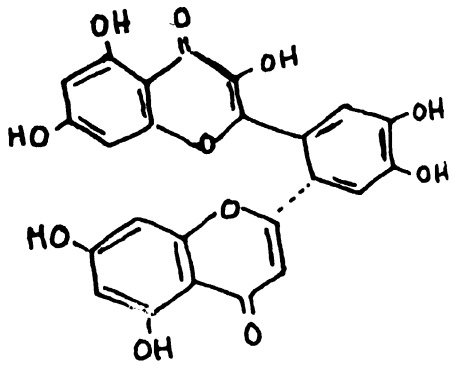
(42) R=H (43) R-OH

Takine *et al* used tea oxidase enzyme to couple the flavonoid glycoside myricitrin (44) with catechol to yield erycitrin (45). Acid hydrolysis of this furnished agly cone erycetin (46).

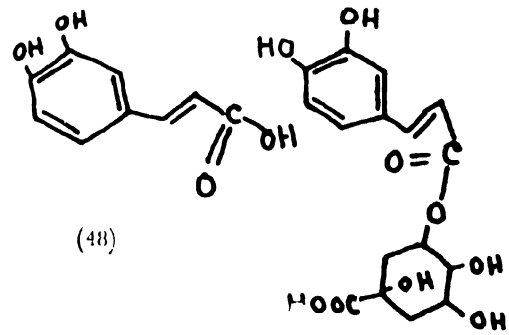


(45) $R=C_5H_{11}O_4$ (46) R=H

In analogy with this and possible occurrence of these pigments, various other benzotropolones arising from the coupling of quercetin and (20) to give (47), caffeic acid (48) and epigallocatechingallate (21) to afford (49) and chlorogenic acid (50) and (21) to (51).



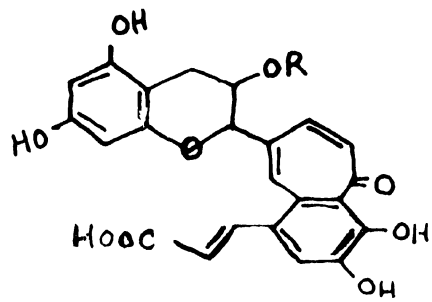
(47)



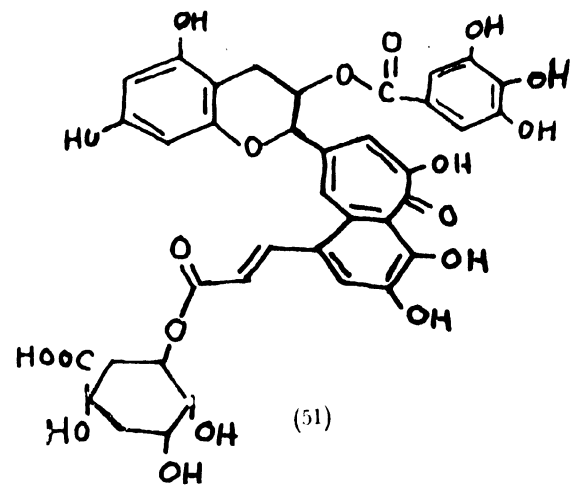
(48)



(50) Chlorogenic acid



(49) R-galloyl
(52) R = H



(51)

**IR spectrum of flavanotropolones** : Generally all of these compounds showed the presence of chelated OH (3400--3300 $cm^{-1}$) chelated carbonyl at 1620 $cm^{-1}$ and in the case of galloyl esters, an aromatic ester carbonyl at 1700 $cm^{-1}$.

**UV absorption spectrum** : Ahypsochromic shift is observed which going from benzotropolone (460 nm) to its 6-carboxylic acid (400 nm). Introduction of galloyl group at position 3 intesnsifies the band at 280 nm.

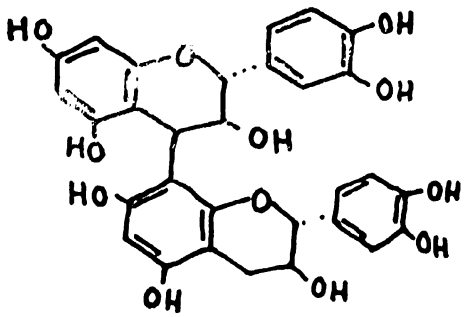
**Mass spectrum**: All theset theaflavins and their gallates show a similar fragmentation pattern being dominated by loss of 166 a.m.u. retro-Diels' Alder reaction. In the case of gallate methyl ethers the pattern is dominated by cleavage of ( -212 a m.u.) involving the trimethoxybenzoyloxy residue and by retro-Diels' Alder reaction ( -166 a.m.u). In case of categallin the spectrum is dominated by the loss of (--248 a.m.u.) 1'2'-dihydroxy 3-4 benzotropolone-6-carboxylica acid. Also a pronounced peak due to loss of a CO fragment (--28 a.m.u.) to yield phenol radical is observed.

**N.M.R** : In all these cases a low field signal at $\delta$ 5 attributed to the hydrogen bonded hydroxyl group is observed. Other signals due to different aromatic protons are also observed. NMR spectrum has been of great importance in assigning the stereochemistry at C-2 and C-3 carbon atoms of the heterocyclic ring. An axial equotorial relationship (*trans*) between protons at the 2 & 3 positions (*cis*) leads to a singlet ($J2, 3 = 0$) for C-2 H-an axial-axial relationship between these two protons leads to a coupled system ($J_{2,3}$ 9Hz), thus confirming the asymmetry at these two centres.

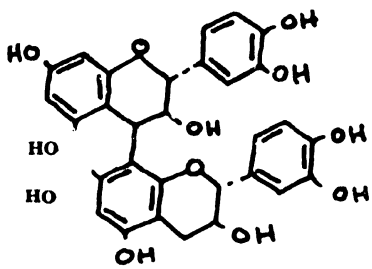
### (c) Thearubigins and model compounds

It has been assumed that thearubigins are formed from the flavan-3-ols present in green leaf. Thearubigins generally showed characteristic streaking on paper chromatography. In view of this, several compounds containing flavanotropolone residue have been synthesized which may be present in black tea. It has also been shown that thearubigins contain proanthocyanidin type units. This thus led to the isolation of proanthocyanidins.

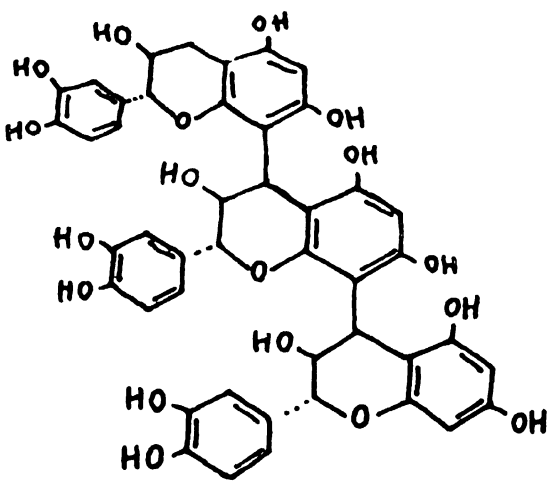
Polymerisation of catechin or epicatechin on heating with HCl yielded a buff coloured amorphous solid which showed characteristics of thearubigins. However, this could not be degraded.



(53) (+) catechin (+) catechin



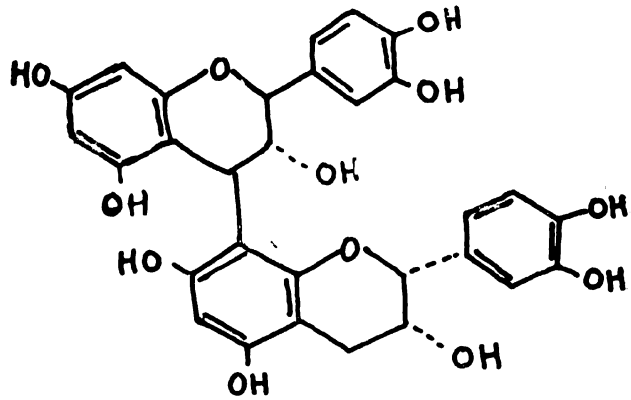
(55) catechin+epicatechin



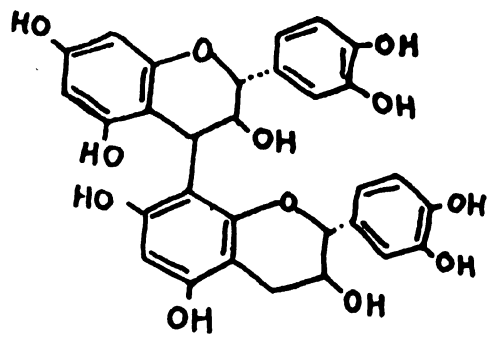
(58) trimer ( from catechin )

The dimer (54) and (56) were also isolated from cocoa beans. On hydrolysis they furnished cyanidin (28) derived from epicatechin. Also epicatechin (14) and catechin (16) were obtained from $B_2$ and $B_1$ respectively.

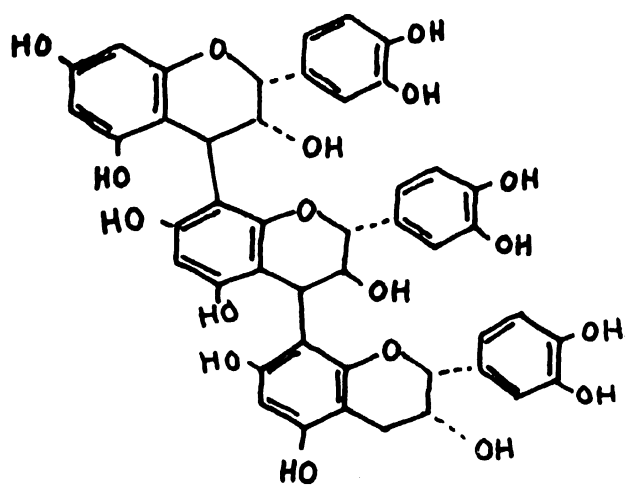
Proanthocyanidins are flavan-3-ol dimers and higher oligomers which on hydrolysis yield anthocyanidins. Following dimers and trimers have been reported to occur in tea by several workers. These are formed by the various combinations of catechin or epicatechin.



(54) epicatechin + epicatechin



(56) epicatechin + (-)catechin

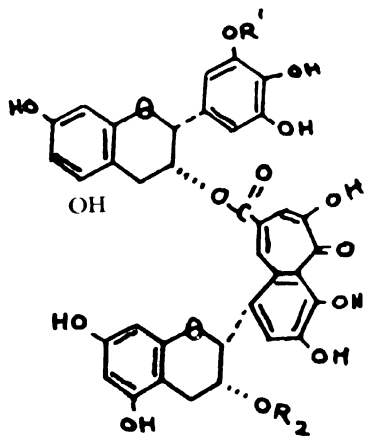


(57) trimer (from catechin)

These proanthocyanidins have been assumed to be derived from flavon -3- ols. Since tea contained catechins, gallocatechins and their gallates, proanthocyanidins derived from all combination of these flavan-3-ols may be present.

In view of this various flavanotropolone oligomers were synthesized using alkaline potassium ferricyanide as the oxidising agent.

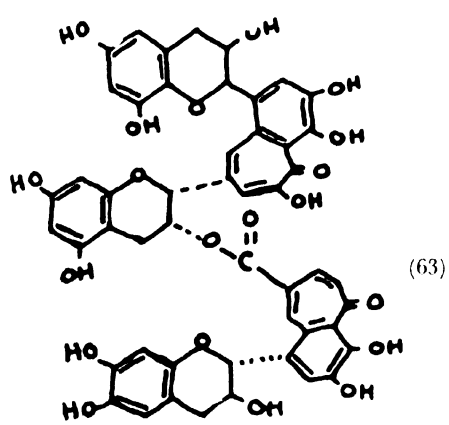
Coupling of (15) with (16) afforded (59) formed by coupling through the galloyl residue of epicatechin gallate (15).



(59) $R_1 = R_2 = H$

(61) $R_1 = OH$, $R_2 = H$

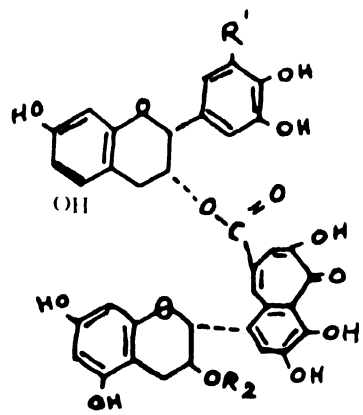
Condensation of epigallocatechin gallate (21) with catechin (16) or epicatechin (14) furnishes mainly corresponding theaflavin monogallate. Besides this, other orange products were isolated which were assigned structures (61) and (62) respectively. Further another possible product (63) formed by the coupling of two molecule of catechin and one molecule of epigallocatechin gallate may also be obtained.



(63)

These flavanotropolones show the same paper chromatographic behaviour as thearubigins. Thus there is possibility that these tropolone ester linkages are formed during tea fermentation by the enzyme tea oxidase, but may be in very small amounts as compared with theaflavins.

When epicatechin gallate (15) was alone oxidized four products were isolated having IR and UV spectrum similar to those of flavanotropolone system. The first one was assigned structure (60). The other three were similar to (60) and hence may be belonging to trimeric or higher species.



(60) R' H, $R^2$ galloyl

(62) R' OH, $R_2$ H.

**MS** : Mass spectra of their methyl ethers are all identical and are dominated by the loss of (-166 a.m.u.) resulting from retro-Diels' Alder fragmentation. The presence of the gallate in the nonmethylated compound was detected by the appearance of ions at m/e 153 formed from this grouping.

**N.M.R.** : The NMR spectra were consistent with the structure proposed; signal broadening occurs with the increase in the molecular size. The dimeric product showed clearly resolved spectrum. The broadening of the signals showed polymerization.

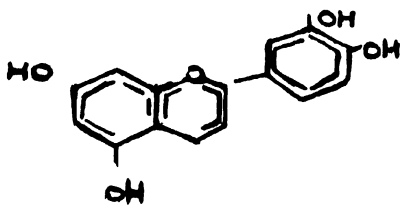
(d) **Study with Green leaf estractives** : The quality of black tea depends on the polyphenolic contents of green leaf which undergo chemical change during the fermentation stage. With this view polyphenolic contents of green leaf were investigated. The ethyl acetate extract of green leaf on column chromatography over sephadex LH-20 yielded ten fractions which were located by monitoring the eluent at 260 nm. Fractions 2 and 3 contained tricetinidin ( UV 280, 510 nm ) (4) and luteolinidin (64) (UV 280, 490 nm ) respectively. Fraction 8 mainly contained epigallocatechin gallate (21) and a trace of theaflavin along with other proanthocyanidin dimers and trimers. Hydrolysis of this fraction with dil HCl yielded cyanidin (28), delphinidin (29) and tricetinidin (4). Epicatechin was also detected in this fraction

Fraction 10 contained traces of thearubigin like compounds. Acidic treatment yielded cyanidin, del-

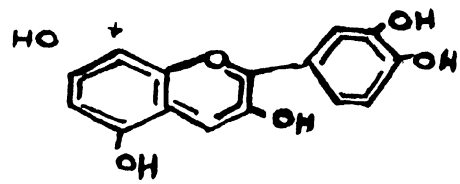
phinidin and small quantities of flavanols, (−) -epigallocatechin (20), (−)-epicatechin gallate (15) and epigallocatechin gallate (21).

Fraction 7 and 9 were again subjected to column chromatography over sephadex and yielded (28), (64) and (16) from the former while the latter yielded (−) epigallo catechin, 3,5 digallate along with (28), (29), (20), (15) and (21).

Isolation of these anthocyanidins led to speculation on the biogenesis of these compounds. It wash shown that

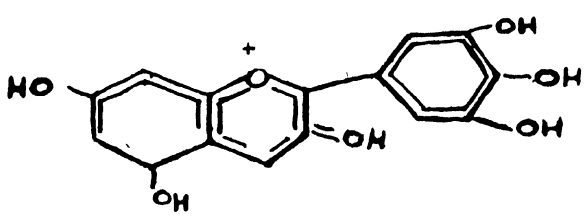


(64)



(28)

flavanol gallate are converted to anthocynidins when stored for long time. However these were not formed when pure flavanol-gallates as solid or solutions were subjected to UV light; thus confirming that the cleavage of flavanol gallate is a thermal process. However, the anthocyanidins were also not obtained from flavanols not containing the galloyl grouping.



(29)

From green leaf by a modified extraction procedure, the four bisflavanols were also isolated. NMR spectrum was fairly complex which is possible if the heterocyclic ring in the lower flavan-3-ol adopts a skew boat conformation and the aryl group at C-2′ is in a quasiaxial position. Thus there is possibility of the presence of two conformers in terms of restricted rotation about the C-4 linkage between the two flavan-3-ol units.

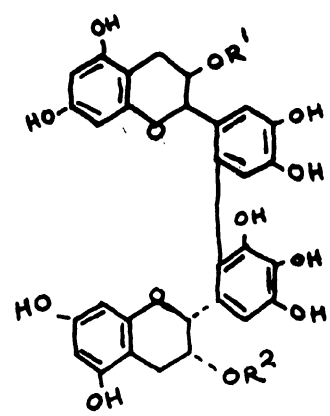
### (c) Study with Black Tea extractives

The tea colour is mainly dependent on the polyphenolic constituents of black tea. With this idea a detailed study of black tea polyphenolic content was undertaken. This was done by following two procedures. (1) ethylacetate soluble polyphenols (2) 60% aq. acetone soluble phenols. In the study special attention was paid on the isolation, purification and structural work on thearubigins.

**Ethyl acetate-soluble polyphenols**

This being fractionated by column chromatography over sephadex LH-20 yielded 17 fractions by elution with chloroform-methanol light petroleum (1:2:1) and fraction 18 by final elution with 60% aq. acetone.

All the flavan-3-ols present in green leaf were found present in the blak tea extract. Further fractionation of Fractions 13, 14, 15 and 16 yielded, theaflavin 3′ monogallate (23), 3, 3′, digallate (25) and 3-monogallate (24). Fractions 14 and 16 yielded bisflavano monogallato (2) and bisflavanol digallate (1).



(2) Bisflavanol B (monogallate)
$R' = H$, $R^2 = $ galloyl

(1) Bisflavanol A (digallate)
$R' = R^2 = $ galloyl

(3) Bisflavanol C
$R' = R^2 = H$

Tannase hydrolysis of (1) yielded gallic acid and (3). Fraction (13) yielded a compound whose IR and UV spe-

ctrum were characteristic of purpurogallin moiety in the molecule. This was later found to be pyrogallin-3-gallate (13).

Fraction (16) yielded an orange red material showing IR andUV spectrum indicative of a 1', 2' -dihydroxy-3, 4-benzotropolone-6-carboxylic acid grouping. This could have structure either (59) or (60) mentioned earlier.

**Aqueous Acetone extract** : The tea powder extract was chromatographed on a sephadex LH 20 column in 60% aq. acetone.This yielded a fraction (max 384 nm) which when rechromatographed yielded 10 fractions. Fractions 6, 7 and 8 when rechromatographed yielded (21) from Fr 7 and 8 flavanol B (2) from Fr. 8. Fraction 6 however yielded bisflavanol C (3) and a proanthocyanidin fraction which on treatment with hot ethanolic HCl yielded epicatechin (14). Thus indicating the presence of a dimeric proanthocyanidin formed from two catechin units, with (– ) epicatechin as the unit linked at the C-8 position therefore could have structure (55).

From the aqueous acetone extract by further chromatography on sephadex LH 20 (methanol) was isolated aglycone quercetin.

## (f) Tea Quality study

Also in the study the tea samples were examined by column chromatographic method at various stages of tea manufacture. Samples A1 and A2 was derived from freshly plucked cut green leaf while samples B and C were obtained from withered and withered fermented leaf respectively. These were treated in the same manner as black tea and were chromatographed in 60% aq acetone in sephadex LH20 and the eluents were monitored by UV absorption.

From samples A to C an increase in the thearubigin and theaflavin contents were observed. However, sample A and B showed very little difference. The theaflavins were most prominent in sample C and sample C also showed a decrease in spot intensives of catechins gallocatechins and their gallates. Thus theaflavins were found to be present in moderate amounts in sample A (cut green leaf) which shows that enzymic oxidation process commences as soon as the cell membrane are raptured. Thearubigin formation also begins at the withering stage, theaflavin gallates were only formed in the fermentation stage.

A study was made to find out the pigment profiles from tea samples of different fermentation times.

The samples were fermented at 80°F from zero minutes for sample 1 to 150 minutes for samples upto 26. Best results were found for sample 12 which had the best all round characteristics although No. 8 was the brightest and No. 13 had more strength without significant loss of briskness. Samples were studied in the same manner as above. Thearubigin content was found to increase throughout the fermentation stage. However theaflavin content was found to increase upto a certain stage and then gradually decreased. Sample 8 was found to contain the highest amount of theaflavin responsible for its bright colour. Sample 12 however showed a good balance between thearubigin and theaflavin content responsible for its best all round quality.

## (g) The role of the chlorophylls in black tea manufacture

This aspect was considered to be important with a view that chlorophyll is transformed when going from green leaf to black tea. The common transformation products found in tea include pheophytins and the pheophorlides. However formation of other product occuring due to molecular break down during firing stage cannot be ruled out. It is these transformation product which may constitute to some extent the tea colour. Thus the factors such as pH, chlorophyllase activity, heavy metal ion conc. and the method of manufacture of tea might affect the chlorophyll transformation. The amount of chlorophyll present in tea leaves depends to some extent on the weather as well as on its situation. The plants growing in dull rainy weather or at low elevations contain more chlorophyll as compared to those growing in sunny weather and at high elevation.

# Appendix - A

## LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY ADVISORY DEPARTMENT

### South Bank

| Project | Site | Index No. | | Year of starting |
|---|---|---|---|---|
| NPK manuring of mature tea | Panitola | AS | 108 | 1973 |
| do | Thowra | AS | 111 | ,, |
| do | Rupai | AS | 114 | ,, |
| do | Diffloo | AS | 120 | ,, |
| do | Meleng | AS | 142 | 1976 |
| Foliar application of Zinc | Panitola | AS | 109 | 1973 |
| Shade in Relation to Tea Nutrition | Thowra | AS | 110 | ,, |
| do | Bordubi | AS | 113 | ,, |
| do | Methoni | AS | 119 | ,, |
| Plucking Experiment | Lohpohia | AS | 133 | 1974 |
| Infilling Experiment | Halmari | AS | 129 | ,, |
| Rejuvenation Experiment | Tara | AS | 128 | ,, |
| do | Teloijan | AS | 130 | ,, |
| do | Dilli | AS | 160 | 1978 |
| Cultivation Experiment | Deohall | AS | 134 | 1975 |
| Young Tea Manuring (YTD) | Fatikjan | AS | 144 | 1976 |
| do | Meleng | AS | 145 | 1977 |
| Young Tea Manuring (Response) Surface NPK) | Balijan H | AS | 153 | 1978 |
| do | Sepon | AS | 161 | ,, |
| New Plucking Experiment (UP) | Nahortalli (Nahorhabi Sec) | AS | 170 | ,, |
| do (LP) | do (Killybari Sec) | AS | 171 | ,, |
| Micronutrient Trial | Sepon | AS | 161 | 1977 |
| | Dilli-IB | AS | 154 | ,, |
| | Dilli-5 | AS | 155 | ,, |
| | Dilli-9 | AS | 156 | ,, |
| | Daimukhia-9 | AS | 157 | ,, |
| | Daimukhia-5 | AS | 158 | ,, |
| | Daimukhia-13 | AS | 159 | ,, |
| | Meleng | AS | 162 | ,, |
| | Sycotta | AS | 163 | ,, |
| | Dhekiajulli | AS | 164 | ,, |
| | Borsapori | AS | 165 | ,, |
| | Bokakhat | AS | 166 | ,, |
| | Methoni | AS | 167 | ,, |

### North Bank

| | | | | |
|---|---|---|---|---|
| NPK manuring of mature tea | Monabarrie | AN | 116 | 1973 |
| -do- | Naharani | AN | 123 | ,, |
| Shade in relation to level of tea nutrition | Partabgarh | AN | 118 | ,, |
| Rejuvenation Experiment | Kacharigaon | AN | 135 | 1974 |
| -do- | Tezpur Gogra | AN | 136 | ,, |
| -do- | Baghmari | AN | 137 | ,, |
| Infilling Experiment | Kacharigaon | AN | 140 | ,, |
| -do- | Baghmari | AN | 141 | ,, |
| Plucking and Pruning | Dhoolie | AN | 139 | ,, |
| Nitrogen with and without mulch | Sessa | AN | 138 | 1975 |
| Micronutrient Trial | Durrang-IB | AN | 146 | 1977 |
| -do- | Durrang-IA | AN | 147 | ,, |
| -do- | Singrijan | AN | 148 | ,, |
| -do- | Tarajullie— 2 | AN | 149 | ,, |
| -do- | Tarajullie—22 | AN | 150 | ,, |
| -do- | Tarajullie—19 | AN | 151 | ,, |
| Spacing Trial | North Bank HQ | AN | 152 | ,, |
| New Plucking Trial (UP) | Hattibari Sec. 22 | AN | 168 | 1978 |
| -do- (LP) | -do- | AN | 169 | ,, |

### Cachar

| Project | Site | Index No. | | Year of starting |
|---|---|---|---|---|
| NPK manuring of mature tea | Silcoorie | C | 38 | 1973 |
| -do- | Longai | C | 39 | ,, |
| Clonal response to N in different agro-climatic region | Coombergram | C | 20 | 1962 |
| Rejuvenation Experiment | Isabheel | C | 47 | 1974 |
| Plucking and Prunning | Hattikhira | C | 45 | ,, |
| -do | Silcoorie | C | 46 | 1975 |
| Young tea manuring (YTD) | Borjallingah | C | 49 | 1977 |
| Young tea manufacturing (Response surface—NPK) | Arcuttipore | C | 50 | ,, |
| Bringing up of young tea (Studies on frame development) | Arcuttipore | C | 51 | ,, |
| Micronutrient Trial | Isabheel- 4 | C | 52 | ,, |
| | Isabheel- 7 | C | 53 | ,, |
| | Isabheel 11 | C | 54 | ,, |
| Spacing Trial | Borjallingah | C | 55 | ,, |
| New plucking trial (LP) | West Jallingah Sec. 2 | C | 56 | 1978 |
| -do- (UP) | do Sec.1 | C | 57 | ,, |

### Dooars & Terai (West Bengal)

| | | | | |
|---|---|---|---|---|
| NPK manuring of mature tea | Bagrakote | D | 55 | 1973 |
| -do- | Samsing | D | 56 | ,, |
| -do- | Nimtijhora | D | 57 | ,, |
| -do- | Gungaram | TR | 7 | ,, |
| Nitrogenous fertilizer | Baradighi | D | 33 | 1962 |
| Clonal response to N in different agro-climatic region | Nya Sylee | D | 24 | ,, |
| Cultivation and weed control | Chuapara | D | 42 | 1970 |
| Shade in relation to level of tea nutrition | Gandrapara | D | 50 | 1973 |
| Infilling Experiment | Kartick | D | 41 | 1969 |
| -do- | Jainti | D | 40 | ,, |
| -do- | Fagu | D | 37 | ,, |
| -do- | Sahabad | TR | 4 | ,, |
| -do- | Mohurgong & Gulma | TR | 3 | ,, |
| Rejuvenation Experiment | Dalgaon | D | 43 | 1972 |
| | Metelli | D | 44 | ,, |
| | Killcott | D | 45 | ,, |
| | Rydak | D | 46 | ,, |
| | Kumlai | D | 47 | ,, |
| | Gungaram | TR | 5 | ,, |
| Plucking & Pruning | Birpara | D | 58 | 1974 |
| -do- | Dalsingpara | D | 59 | ,, |
| -do- | Hansqua | TR | 60 | ,, |
| Clone Vs Nitrogen Trial | Nagrakata | D | 48 | 1973 |
| Irrigation Trial | Dam Dim | D | 63 | 1976 |
| -do- | Jainti | D | 64 | 1977 |
| Long Term Trial | Nagrakata HQ | D | 61 | 1974 |
| New long term trial | -do- | D | 62 | 1975 |
| Young tea manuring(YTD) | -do- | D | 65 | 1977 |
| -do- | Nagaisurrie | D | 66 | ,, |
| Young tea manuring (Response surface- NPK) | Rydak | D | 67 | 1978 |
| -do- | Lakhipara | D | 68 | 1977 |
| -do- | Bhogotpore | D | 69 | 1978 |
| Bringing up of young tea | Haldibari | D | 70 | 1977 |
| Micronutrient Trial | Bharnabari- 5 | D | 71 | 1977 |
| | Bharnabari- 6 | D | 72 | ,, |
| | Bharnabari-7A | D | 73 | ,, |
| | Grassmore | D | 74 | ,, |
| | Nagrakata | D | 75 | ,, |
| | Bhogotpore | D | 76 | ,, |
| Spacing Trial | Nagrakata HQ | D | 77 | ,, |
| Shade and Nutrition | Satali | D | 78 | 1978 |

**Darjeeling**

| Project | Site | Index No. | Year of starting |
|---|---|---|---|
| NPK Manuring of mature tea | Chontong | Dj 34 | 1973 |
| -do- | Nagrifarm | Dj 35 | ,, |
| Nitrogeneous fertilizer | Lingia | Dj 29 | 1967 |
| Clonal response to N in different agro climatic region | Nagrifarm | Dj 19 | 1963 |
| P & K with and without weedicide | Chamong, Sungma, Nagari | Dj 31 | 1970 |
| Infilling Experiment | Bannockburn | Dj 36 | 1974 |
| Rejuvenation Experiment | Bannockburn | Dj 38 | 1974 |
| Young tea manuring | Gielle | Dj 48 | 1978 |
| Young tea manuring (Response Surface NPK) | Phoobsering | Dj 47 | ,, |
| Micronutrient Trial | Ringtong | Dj 43 & 44 | 1977 |
| | Balsun | Dj 45 & 46 | ,, |
| | Goomte | Dj 41 & 42 | ,, |
| | Maharani | Dj 40 | |

# Appendix - B

## LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY THE OTHER DEPARTMENTS

### BOTANY DEPARTMENT

List of Estates under clonal selection scheme

| Sl. No. | Name of Estate | Year of starting |
|---|---|---|
| **South Bank, Assam** | | |
| 1. | Heeleakah | 1972 |
| 2. | Duklingia | 1973 |
| 3. | Basabari | 1974 |
| 4. | Borbam | 1975 |
| 5. | Dahingrapara | 1975 |
| 6. | Sotai | 1975 |
| 7. | Bukhial | 1975 |
| 8. | Dilli | 1976 |
| 9. | Cherideopurbat | 1976 |
| 10. | Tingalibam | 1976 |
| 11. | Longboi | 1976 |
| 12. | Dinjan | 1976 |
| 13. | Gabruparbat | 1976 |
| 14. | Halwating | 1977 |
| 15. | Amgoorie | 1977 |
| 16. | Mokrung | 1977 |
| 17. | Gatoonga | 1977 |
| 18. | Rungamatty | 1977 |
| 19. | Neghriting | 1977 |
| 20. | Dooria | 1977 |
| 21. | Gopalkrishna | 1977 |
| 22. | Amlukie | 1977 |
| 23. | Dejoo Valley | 1977 |
| 24. | Gouranga | 1977 |
| 25. | Kaliapani | 1977 |
| 26. | Teloijan | 1977 |
| 27. | Deepling | 1977 |
| 28. | Borsillah | 1977 |
| 29 | Namburnadi | 1977 |
| 30. | Dalowjan | 1977 |
| 31. | Borkatoni | 1977 |
| 32. | Monabari | 1977 |
| 33. | Lengrai | 1977 |
| 34. | Sangsua | 1977 |
| 35. | Barpathar | 1978 |
| 36. | Joonktollee | 1978 |
| 37. | Lengree | 1978 |
| **North Bank, Assam** | | |
| 1. | Durrung | 1975 |
| 2. | Birjhora | 1976 |
| 3. | Nagrijuli | 1976 |
| 4. | Dhunseri | 1976 |
| 5. | Tarajuli | 1976 |
| 6. | Gingia | 1976 |
| 7. | Halem | 1976 |
| 8. | Chapar | 1976 |
| 9. | Choibari | 1976 |
| 10. | Kokrajhar | 1976 |
| 11. | Mornoi | 1976 |
| 12. | Tezpore & Gogra | 1978 |
| 13. | Sonabheel | 1978 |
| 14. | Sonajuli | 1978 |
| 15. | Borjuli | 1978 |
| 16. | Kolony | 1978 |
| 17. | Kacharigaon | 1978 |
| 18. | Phulbari | 1978 |
| 19. | Dhulapadang | 1978 |
| 20. | Rupajuli | 1978 |
| 21. | Baghmari | 1973 |
| 22. | Borgang | 1978 |
| 23. | Gohpur | 1978 |
| 24. | Nilpur | 1978 |
| **Cachar, Assam** | | |
| 1. | Chandighat | 1976 |
| 2. | Burtoll | 1976 |
| 3. | Poloi | 1976 |
| 4. | Narsingpore | 1976 |
| 5. | Longai | 1976 |
| 6. | Borjallingah | 1978 |
| **Dooars & Terai, West Bengal** | | |
| 1. | Gopalpur | 1976 |
| 2. | Chuapara | 1976 |
| 3. | Central Dooars | 1976 |
| 4. | Kartick | 1976 |
| 5. | Rydak | 1976 |
| 6. | Leesh River | 1976 |
| 7. | Baintgoorie | 1976 |
| 8. | Birpara | 1976 |
| 9. | Garganda | 1976 |
| 10. | Subhasini | 1976 |
| 11. | Dalsingpara | 1976 |
| 12. | Engo | 1977 |
| 13. | Samsing | 1977 |
| 14. | Aibheel | 1977 |
| 15. | Newland | 1977 |
| 16. | Tirrihana | 1976 |
| 17. | Mohurgang & Gulma | 1976 |
| 18. | Bijoynagar | 1976 |
| 19. | Panighatta | 1976 |
| **Darjeeling, West Bengal** | | |
| 1. | Happy Valley | 1975 |
| 2. | Soom | 1975 |
| 3. | Lingia | 1975 |
| 4. | Balsun | 1975 |
| 5. | Singbuli | 1975 |
| 6. | Goomtee | 1977 |

### ENTOMOLOGY DEPARTMENT

List of Experiments

| Sl. No. | Experiments | Location of site | Site | Index | Year started |
|---|---|---|---|---|---|
| 1. | Effect of foliar application of Micro-nutrient on mite incidence | South Bank | Sycotta/Meleng Bokakhat | 6 | April, 1978 |
| 2. | Studies on seasonal incidence of scale insects | South Bank | Cinnamara | 6 | March, 1977 |
| 3. | Studies on distribution and abundance of shothole borer | South Bank | Moabund | 6 | March, 1977 |
| 4. | Studies on the incidence of shade tree pests | South Nank | Govindapore | 6 | April, 1977 |
| 5. | Looper control trial | South Bank | Kotalgoorie | 6 | March, 1969 |
| 6. | Thrips control trial | Darjeeling | Badamtam | 6 | May, 1978 |
| 7. | Scale Insect Control trial | South Bank | Dooria | 6 | Sept. 1978 |
| 8. | Cockchafar Control trial | Dooars | Meenglas | 6 | Sept. 1978 |
| 9. | Lymentriid caterpillar control trial | Darjeeling | Sungma | 6 | March, 1979 |
| 10. | Nematode control trial (Palliative) | North Bank/ South Bank | Addabarie/Nagadhoolie | 6 | Aug. 1978 April, 1978 |

## MYCOLOGY DEPARTMENT

| Sl. No. | Experiment | Location | Site | Index No. | Year of starting |
|---|---|---|---|---|---|
| 1. | Evaluation of different formulations against red rust | South Bank | Bokahola | MR 026 | 1978 |
| 2. | Study of the synergistic action of anti-biotics in combination with standard copper fungicides in controlling red rust | ,, ,, | Dahingeapar | MR 027 | 1978 |
| 3. | Study of the effect of foliar spray of fertilizers in mitigating red rust injection in presence or absense of standard fungicide spray | ,, ,, | Bokahola | MR 023 | 1978 |
| 4. | Testing of a new fungicides against Thorny stem blight | Darjeeling | Happy Valley | MC 006 | 1975 |
| 5. | Screening of fungicides against black rot | South Bank | Powai | MB 020 | 1978 |
| 6. | To evaluate the synergistic action of anti-biotics in combination with a lower dilution of a copper fungicide in controlling black rot | ,, ,, | Bogapani | MB 021 | 1978 |
| 7. | Screening of fungicides against blister blight | Darjeeling | Soom | MF 009 | 1978 |
| 8. | Effect of different treatments on the control of blister blight and yield return | ,, ,, | Arya | MF 005 | 1976 |
| 9. | Chemical control of primary root disease | South Bank | Nahorkutia | MP 002 | 1974 |
| 10. | -do- | ,, ,, | Borhat | MP 003 | 1975 |
| 11. | -do- | North Bank | Tarajullie | MP 004 | 1975 |
| 12. | -do- | ,, ,, | Thakurbari | MP 006 | 1975 |
| 13. | -do- | Darjeeling | Balsun | MP 005 | 1974 |
| 14. | -do- | South Bank | Dilli | MP 007 | 1976 |

## ENGINEERING DEPARTMENT

| Sl. No. | Experiment | Place | |
|---|---|---|---|
| 1. | Trial of continuous Tea Roller | (a) Hunwal TE | South Bank |
| | | (b) Halem TE | North Bank |
| | | (c) Chabua TE | Upper Assam |
| 2. | Trial of B.L.C. Mark II | Monabarie TE | North Bank |
| 3. | Trial of Cutter Attachment | do | |

## AGRONOMY DEPARTMENT

| Sl. No. | Experiment | Place | Year of starting |
|---|---|---|---|
| 1. | Cultivation Experiment in collaboration with Advisory Deptt. | Deohall TE | 1977 |

## STATISTICS DEPARTMENT

| Sl. No. | Experiment | Place | Year of starting |
|---|---|---|---|
| 1. | Uniformity Trial | Nagrifarm TE (West Bengal) | 1964 |

## SOILS DEPARTMENT

| Sl. No. | Experiment | Place |
|---|---|---|
| 1. | Drainage Experiment | Haroocharai TE |
| 2. | -do- | Lengrai TE |
| 3. | -do- | Khongea TE |
| 4. | -do- | Hunwal TE |
| 5. | -do- | Mogulkata TE |

# Appendix - C

## PUBLISHED PAPERS & PAPERS IN THE PRESS

Awasthi, R.C., 1978. Productivity of Mature Tea in North East India, Symposium Bulletin of PLACRO-SYM-1, Kottayam (Kerala)

(Abs. Both mature and young tea have contributed significantly to increase the overall yield of tea in N.E. India. 87% of the TRA member estates increased the mature tea yield between 0.5 per cent to 10 per cent and more per annum in N.E. India during the period 1970 to 76.)

Dev Choudhury, M.N. and Bajaj, K.L. 1979. Incorporation of $^{14}C$- compounds into amino acids and polyphenols of excised tea (*camellia sinensis*) shoots. Plant Biochemical Journal, 6 (1), 16-23.

(Abs. The Study of the biosynthesis of amino acids by feeding U-$^{14}C$-glucose, $^{14}C$-sodium carbonate, 1-$^{14}C$-sodium propionate and $^{14}C$-phenylalanine to excised tea shoots indicated that theanine (N-ethyl glutamine) was not biosynthesissed in tea shoots. Incorporating labelled glucose to excised tea shoots, labelled aspartic acid, glutamine, alanine, tyrosine, valine, leucine isoleucine, glutamic acid and phenylalanine were detected. Theseamino acids were also biosynthesised when labelled sodium carbonate was fed to tea shoots. In the former case, glutamine but in the latter case glutamic acid was highly labelled. Catechin and p-coumaryl quinic acids were found to be partly biosynthesised from phenylalanine. With labelled 1-$^{14}C$-sodium propionate, radioactivity was mainly associated with aspartic acid, tyrosine, glutamine, chlorogenic acids and theogallin. Some of the biosynthetic pathways of amino acids and chlorogenic acids were briefly discussed.)

Rao, V.S. 1979. Integrated Weed Control in Tea. Proc Conf. Indian Soc. Weed Sci. held in January 1979 at Parbhani, Maharashtra, PP. 61.

(Abs. The most effective approach for integrated system of weed control in a crop should be to evolve the highly effective and least expensive weed control schedules that do not disturb the ecological and environmental balance. As herbicides and human labour are becoming increasingly expensive, there is a greater need to economic weed control practices for financial and environmental reasons, weed research programme at Tocklai is directed to meet this objective. The results of various experiments of time and duration of weed competition, herbicide selectively, weed succession, herbicide mixtures, sequential application of herbicide new herbicides, surfactants and fertilizer additives, herbicide persistance, spraying techniques, manual weed control economic evaluation of weed control practices, are presented and discussed).

Rao, V.S. and Kotoky, B. 1979. Enhancement of Glyphosate Activity by Solubilization and Fertilizer Additives. Proc. Conf. of Indian Soc. Weed Sci. held in January 1979 at Parbhani, Maharashtra, PP. 11,.

(Abs. At 0.4 kg/ha, the solubilized glyphosate showed substantially higher activity on *Imperata cylindrica* (thatchgrass) a commonly occuring perennial grass weed in tea, than that of the normal glyphosate formulation; its weed control efficacy at this rate was similar to that of the latter at 0.8 kg/ha. These results indicated that solubilization enhances the weed control efficacy of glyphosate and helps to reduce its optimum rate of application substantially.

In separate experiments ammonium sulphate, urea, supper phosphate (single) and diammonium hydrogen phosphate were tank mixed at 0.5% and 1% with glyphosate (0.4 kg/ha) solution. Addition of ammonium sulphate and diammonium hydrogen phosphate increased the activity of glyphosate on *Imperata*. Better weed control was observed when they were mixed at 0.5%. These results suggest that the ammonium salt present in these two fertilizers is probably contributing to this enhanced glyphosate activity by way of its effect on membrane permeability).

Satyanarayana, G., Baruah, G.C.S., and Barua K.C. 1978. Screening fungicides for control of blister blight of tea in North-East India. Methods for evaluating plant fungicides, nematicides and bactericides. Published by American Phytopathological Society, p. 72-73.

(Abs. Methods of assessing the blister blight incidence in Darjeeling are described. Control operations with different formulations and spraying techniques are detailed.)

Venkataramanan, M.N., and Satyanarayana, G. 1978. Autecological studies on Sphaerostilbe repens caeesing Violet root rot of tea. Acta Botanica Indica 1978. 6 (supplement) pp 178-179.

(Abs. Autecological studies on Violet root rot pathogen Sphaerostilbe repens have revealed interesting features which are briefly described and discussed.)

Rao, V.S., Sarmah, S.N. and Kotoky, B. 1979. Effect of Paraquat-MSMA and Paraquat-Oxyfluorfen Mixtures on the Control of Perennial Grasses in Tea. Proc. Conf. Indian Soc. Weed Sci. held in January 1979 at Parbhani, Maharashtra, PP. 61.

(Abs. Several pot and field experiments were conducted to study the effect of tank mixing of MSMA (Monosodium methanearsonate) at 0.50 and 1.0 kg/

ha or oxyfluorfen (RH-2915) (2-chloro-1-(3-ethoxy-4-nitrophenoxyl)-4-(trifluoromethyl) benzene) at 0.38 and 0.75 kg/ha with paraquat at 0.15 and 0.30 kg/ha on the control of *Paspalum conjugatum*, *Setaria palmifolia*, and *Cynodon dactylon*, the very persistent perennial grass weeds in tea.

When paraquat (0.15 kg/ha)—MSMA (0.50 kg/ha) mixture was applied at postemergence on *Paspalum* regrowth was considerably delayed and the final weed control was significantly superior to that when paraquat was applied alone. Similar results were also obtained when paraquat (0.15 kg/ha) and oxyfluorfen (0.75 kg/ha) were tank mixed and sprayed on *Setaria*. While neither MSMA nor oxyfluorfen alone had any affect on *Cynodon*, they showed moderate activity on *Paspalum* and *Setaria* respectively. As the effect of paraquat-oxyfluorfen combination is significantly higher than the combined effect of each of them applied alone, these two herbicides are possibly acting synergistically).

Singh, Bhupal 1978. Drainage Characteristics of Layered soils. A paper presented at the Assam Science Society Symposium on "Harnessing the River Brahmaputra", 25th to 26th Nov. '78 Gauhati, Assam.

(Abs. Most soils in need of drainage can be regarded as composed of at least two layers an upper layer of relatively high permeability over lying a more consolidated and less permeable layer. A model experiment was carried out at the University of New Castle upon Tyne. England to study the drainage characteristics of such soils. It was observed that where a permeable soil layer overlies a less permeable one there is a considerable amount of horizontal flow of water in the top layer, and more the rate of rainfall exceeded the rate of infiltration, the more shallow discharge there was. The drainage of two-lower soil system was found to be a two stage process i.e. the permeable top layer drained first and then the sub-soil. A finite element method was used to generalise the experimental results for the use under field conditions).

Basu, S.D. 1979. Control of *Meloidogyne incognita* (Kofoid and White) Chitwood on tea seedlings with some systemic nematicides. Proceedings of Second All India Nematology Symposium at Bhubaneswar, Orissa on 21st and 22nd March (in press).

(Abs. Infield trials using Aldicarb, Carbofuran, Phorate and Mocap for palliative control of *Meloidogyne incognita* (Kofoid and White) Chitwood on tea seedlings, Aldicarb at 1 g and 0.5 g., and Carbofuran at 1g and two split application of 1 g per plant helped significantly increase in shoot height and in number of transplantable plants).

Rahman, F. and Nandi, N.G. 1978. Effect of phosphate, mulching and chemical weed control on yield of tea. Proc. 1st Symposium on Plantation Crop, Kottayam, Kerala, (in press).

(Abs. No treatment effects were observed in the first two years. But in the next three years mulch and herbicides treatments gave significantly higher yield than no mulch and mechanical weeding treatments. There was no response to phosphate application upto 200 kg $P_2O_5$/ha. Mulch × weed control interaction was significant and mulching increased yield in mechanically weeded plots but not in herbicides treated plots).

Singh, I.D. and Bezbaruah, H.P. 1978. Collection of tea genetic resources –problems and procedures Proc. Natl. Symp. Plant and Animal Genetic Resources. Dec. 28-30, I.A.R.I. New Delhi. (in press).

(Abs. The need of preserving tea germplasm due to many factors like uprooting of older sections of tea gardens, seed baris and abandoned plantations in N.E. India and danger of narrowing the genetic base tea populations is discussed. The origin of tea forms and possible areas of collecting tea germplasm are explained.

The District Selection Scheme as initiated by the Tocklai Experimental Station as an approach to preserve tea germplasm is outlined. The selection criteria used and the present achievements of the scheme are presented.

The future collection strategies regarding collection, evaluation and maintenance of tea germplasm are outlined. The need of establishing *Camellia* sanctuary at more than one place in India is suggested).

Singh, Bhupal and J.R. O'Callaghan 1978. Effect of Interflow on Soil Drainage J. Agric. Engng. Res., 23, 397-415.

(Abs. A sand tank study was carried out to compare the performance of different drainge configurations on the rate of removal of water in the steady state and on the rate of draw-down of the water table in the non-steady state. A shallow layer of high permeability overlying a deep layer of lower permeability was used to encourage interflow. A finite element solution was used to examine the effects of different drain spacings and ratios of soil permeabilities on drain performance under field conditions).

Singh, Bhupal and J.R. O'Callaghan 1978. Non Steady Drainage in a Layered Soil. J. Agric. Engng. Res., 23, 417-427.

(Abs. A sand tank study was carried out to compare the performance of different drainage to configurations both on the rate of removal of water and on the rate of draw-down of the water table in a layered soil where a permeable layer was overlying a less permeable subsoil. Narrowly spaced shallow drains in combination with a widely spaced deep drain was the most effective combination).

Singh, I.D. 1978. Production of quality seed in papaya. Seeds & Farms 6 (2).

(Abs. The methods of seed production in dioecious and gynodioecious varieties of papaya have been suggested for quality seed production. The techniques of seed extraction, cleaning, drying and storage along with seed standards have been discussed. Hints for raising yields of fresh fruits and seed given).

Singh, I.D., Sirohi, S.C. and Ranjeet 1978.

I. Collection and evaluation of papaya germplasm in Nainital terai of U.P.

II. Performance of promising papaya varieties in Nainital terai of U.P.

III. Improvement of papaya by selection and hybridization.

IV. Sex expression studies in papaya.

V. Screening of papaya germplasm for papain. Technical Document—All India co-ordinated Fruit Improv. Project Workshop on Banana, Papaya and Pineapple, IHRI, Hissarghatta, Bangalore, July 24-26.

Singh, R.M. and Singh, I.D. 1979. Note on genotypic response to seed size in papaya (*Carica papaya L.*). Seed Research 7:37-40.

(Abs. Genotypic differences were found with respect to seed size and seedling vigour. The 1000 seed weight was found to be an important parameter in screening breeding materials for superior quality seed of papaya).

Singh, I.D. 1978. Breeding approaches for the improvement of dioecious plants. Proc Intl. Conf. Cytogen & Crop Improv. March 3-6, B.H.U., Varanasi. (in press).

(Abs. The distribution of dioecious plant species in the plant kingdom, the genetic significance of dioecism, methods of breeding to be used for the improvement of dioecious plants and the work done so far for the improvement of papaya are high lighted).

Singh, I.D. and Ranjeet 1978. A note on methods of seed cleaning and drying on seed germination in papaya. Pant. J. Res. (In press).

(Abs. In series of greenhouse and field experiments it was found that sundried seeds had higher germination than the freshly extracted seeds. Of the two methods of seed drying shade dried seeds had significantly higher germination than the sun dried. Of the three cleaning agents used for removing the sarcotesta layer of the seed followed by drying the seed in shade, saw dust gave maximum germination followed by wood ash and cow urine. The cleaned and shade dried seeds had higher rate as well as per cent germination than the uncleaned and sun dired seeds).

Singh, I.D. and Ranjeet 1978. A note on the estimation of pollen production by different cultivars of papaya, Pant. J. Res. (in press).

(Abs. Papaya cultivars differed significantly in their ability to produce pollen grains. Of the 7 cultivars studied accession G.D. Naidu-1 produced largest number of pollen grains/another (23, 750) and differed significantly from the rest. Berwani Red was next and differed significantly from Honey Dew, Coorg Honey Dew and Peradeniya. The cultivars Washington and Co. 1 were at par with each other. The results indicated the need of different proportion of staminate to pistillate plants in dioecious populations of papaya for satisfactory pollination, fruit and seed development).

Singh, I.D., Ranjeet and Sirohi, S.C. 1978. Flowering and pollination studies in *Carica papaya L.* Pant J. Res. (in press).

(Abs. The floral morphology and biology of various sex forms of papaya with respect to size of the bud length of peduncles, no of buds per inflorsscence, dry weight of the mature buds, time of anthesis and anther dehiscence, viability of pollen grains and receptivity of the stigma have been studied and possible uses of above informations in papaya breeding have been discussed).

Khadi, B.M. & Singh I.D. 1978. Estimates of variability, heritability and genetic advance in papays (*Carica Papaya L.*). Plant. L. Res. (in press).

(Abs. A wide range of phenotypic variation in most of the studied characters was observed. The phenotypic co-efficient of variability (PCV) for all the characters were higher than the genotypic co-efficient of variability (GCV). High GCV and heritability (broad sense) were observed for fruit yield/plant, fruits/plants, fresh and dry seed weight/fruit, seeds/fruit, leaf area/plant, peduncle length, fruit volume and weight/fruit and thus indicating the possibilities of effective and efficient exploitation of the variability for bringing improvement in these traits.

High heritability coupled with high genetic advance was estimated for leaf area/plant, peduncle lenght, fruit/plant, fruit volume, fruiting length, fresh and dry seed weight/fruit, seeds/fruit and fruit yield/plant which indicated the presence of additive gene effects and thus the possibility of easy fixation by selection in the early generations).

Khadi, B.M. and Singh, I.D. 1978. Path analysis for fruit yield, fruit quality and plant stature in papaya (*Carica papaya L.*) Pant. J. Res. (in press).

(Abs. Path analysis to study the direct and indirect effects of different characters on fruit yield, fruit quality and plant height revealed that fruit yield can be improved by selecting for more number of fruit/plant and weight per fruit. Fruiting length and number of fruits per plant should be considered for bringing improvement in the moderate plant height. Since the above characters have more direct effect on the important economic characters, more weightage should be placed on these characters while selecting a plant for more fruit yield, good fruit quality and moderate plant height).

Khadi, B.M. and Singh, I.D. 1978. Selection indices in papaya (*Carica papaya L.*). Pant J. Res. (in press).

(Abs. The most efficient selection index for fruit yield in papaya was one which comprised of plant height, number of fruits/plant, weight/fruit, fruiting length, total soluble solids and fresh seed weight /fruit. The selection index for fruit quality, measured as total soluble solids comprised of number of fruits/plant, weight/fruit, fruit volume, width of the central cavity of fruit, fresh seed weight/fruit and number of seeds/fruit. The selection index for plant height comprised of height at first fruiting, leaf area/plant, stem girth, number of fruits/plant, fruiting length and fruit yield/plant. These selection indices can be used to get maximum genetic advances over straight selection for respective economic traits).

# Appendix - D

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1978

### Table 1. Tocklai Experimental Station

Latitude 26°47′ N  Longitude 94°12′ E  Altitude 96.5 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 21.5 | 9.1 | 15.3 | 24.1 | 5.2 | 4.7 | 6 | 6.3 | 17.0 | 17.2 | 17.9 | 33.1 | 60.3 |
| | (22.3) | (9.4) | (15.8) | | | (21.6) | (5) | (5.9) | (18.5) | (18.2) | (18.9) | (40.9) | (62.2) |
| February | 24.2 | 12.1 | 18.2 | 28.2 | 8.3 | 12.7 | 5 | 7.1 | 19.8 | 19.4 | 19.8 | 50.7 | 83.3 |
| | (24.1) | (11.9) | (18.0) | | | (32.2) | (7) | (6.2) | (20.4) | (19.8) | (20.2) | (57.3) | (84.0) |
| March | 28.5 | 11.4 | 21.4 | 30.6 | 10.6 | 62.4 | 7 | 7.9 | 23.1 | 22.6 | 22.6 | 88.7 | 133.7 |
| | (27.6) | (15.5) | (21.6) | | | (79.2) | (11) | (6.7) | (24.0) | (23.1) | (23.1) | (97.0) | (129.5) |
| April | 29.9 | 19.1 | 24.5 | 31.5 | 15.0 | 13.1 | 11 | 8.5 | 26.8 | 26.2 | 25.8 | 107.7 | 163.1 |
| | (28.6) | (19.0) | (23.8) | | | (196.3) | (17) | (5.9) | (26.7) | (25.8) | (25.6) | (109.2) | (141.5) |
| May | 30.9 | 22.7 | 26.8 | 36.0 | 19.9 | 147.3 | 20 | 5.0 | 28.9 | 28.4 | 28.2 | 89.0 | 155.2 |
| | (29.9) | (21.8) | (25.8) | | | (284.1) | (20) | (5.0) | (28.6) | (27.8) | (27.6) | (118.1) | (154.2) |
| June | 31.8 | 24.7 | 28.2 | 35.4 | 22.7 | 413.2 | 25 | 4.5 | 30.6 | 29.9 | 29.8 | 85.8 | 151.70 |
| | (31.5) | (24.1) | (27.8) | | | (329.9) | (23) | (4.5) | (30.6) | (29.7) | (29.5) | (107.1) | (148.0) |
| July | 31.8 | 24.8 | 28.3 | 35.2 | 20.6 | 538.1 | 24 | 5.3 | 30.4 | 30.1 | 30.1 | 84.4 | 161.0 |
| | (32.2) | (24.6) | (28.4) | | | (381.2) | (25) | (4.7) | (31.4) | (30.6) | (30.6) | (111.9) | (155.6) |
| August | 32.9 | 25.5 | 29.2 | 36.1 | 23.4 | 268.6 | 23 | 6.4 | 31.8 | 31.4 | 31.2 | 90.1 | 174.6 |
| | (32.0) | (24.6) | (28.3) | | | (315.8) | (23) | (5.1) | (31.4) | (30.6) | (30.6) | (102.3) | (151.1) |
| September | 31.6 | 24.5 | 28.0 | 35.4 | 22.0 | 149.7 | 19 | 4.4 | 30.7 | 30.6 | 30.6 | 77.4 | 128.3 |
| | (31.2) | (23.9) | (27.6) | | | (253.1) | (19) | (5.1) | (30.8) | (30.2) | (30.2) | (89.8) | (136.2) |
| October | 31.1 | 22.0 | 26.6 | 33.5 | 18.0 | 39.0 | 8 | 7.3 | 29.0 | 28.8 | 28.8 | 74.4 | 130.5 |
| | (29.3) | (21.0) | (25.2) | | | (118.7) | (12) | (5.6) | (28.4) | (28.4) | (28.4) | (71.7) | (119.8) |
| November | 25.4 | 16.6 | 21.0 | 30.8 | 12.4 | 73.0 | 7 | 4.6 | 23.6 | 23.8 | 24.5 | 37.8 | 72.4 |
| | (26.3) | (15.3) | (20.8) | | | (27.5) | (4) | (6.1) | (24.0) | (23.7) | (24.6) | (49.0) | (82.2) |
| December | 24.1 | 9.7 | 17.0 | 25.8 | 7.0 | 0.0 | 0 | 7.3 | 19.0 | 19.2 | 20.1 | 35.3 | 62.0 |
| | (23.3) | (10.6) | (17.0) | | | (11.2) | (3) | (6.0) | (19.7) | (19.6) | (20.6) | (37.3) | (61.3) |

## PER CENT RELATIVE HUMIDITY

### Table 1 (a).

| Hours IST | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0613 | 95 | 92 | 89 | 88 | 89 | 92 | 92 | 92 | 93 | 95 | 97 | 97 |
| | (96) | (94) | (91) | (91) | (92) | (93) | (93) | (94) | (95) | (96) | (96) | (96) |
| 1313 | 56 | 49 | 43 | 54 | 66 | 74 | 74 | 70 | 72 | 64 | 70 | 56 |
| | (57) | (54) | (53) | (63) | (71) | (75) | (74) | (75) | (71) | (72) | (64) | (60) |

Notes : (i) Data in brackets show previous averages.

(ii) Soil temp. at different depths are the mean of morning and afternoon records.

(iii) Penman in mm means penman estimation of evaporation from an open pen water surface.

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1973

### Table 2. Silcoorie (Cachar)

Latitude 24°50′ N Longitude 92°48′ E Altitude 39.6 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 23.6 | 9.4 | 16.5 | 26.7 | 7.7 | 0.0 | 0 | 8.3 | 19.4 | ? | ? | 54.5 | 74.6 |
| | (25.8) | (10.9) | (18.4) | | | (17.3) | (2) | (8.0) | (21.2) | | | (61.7) | (78.7) |
| February | 28.0 | 12.1 | 20.0 | 33.1 | 9.3 | 2.1 | 1 | 9.0 | 23.6 | ? | ? | 60.3 | 106.0 |
| | (27.5) | (12.9) | (20.2) | | | (50.8) | (1) | (8.2) | (23.2) | | | (79.9) | (102.5) |
| March | 31.0 | 15.4 | 23.2 | 33.6 | 10.6 | 86.6 | 7 | 8.6 | 27.4 | ? | ? | 82.3 | 153.4 |
| | (30.7) | (16.6) | (23.6) | | | (106.5) | (7) | (8.1) | (27.0) | | | (117.0) | (147.6) |
| April | 32.2 | 20.4 | 26.3 | 35.8 | 17.7 | 237.0 | 13 | 8.6 | 29.2 | ? | ? | 85.1 | 171.6 |
| | (31.6) | (20.4) | (26.0) | | | (289.8) | (15) | (8.0) | (29.1) | | | (111.9) | (160.4) |
| May | 30.3 | 22.3 | 26.3 | 35.9 | 20.4 | 457.0 | 25 | 5.3 | 29.2 | ? | ? | 65.7 | 15.41 |
| | (31.7) | (22.7) | (27.2) | | | (393.3) | (19) | (6.5) | (30.4) | | | (123.7) | (174.5) |
| June | 30.9 | 24.0 | 27.4 | 34.1 | 21.7 | 618.6 | 24 | 4.0 | 30.4 | ? | ? | 64.6 | 137.9 |
| | (31.4) | (24.4) | (27.9) | | | (609.5) | (24) | (4.2) | (30.6) | | | (102.3) | (145.4) |
| July | 31.7 | 23.9 | 27.8 | 34.9 | 22.1 | 565.8 | 24 | 5.4 | 31.7 | ? | ? | 85.6 | 162.8 |
| | (32.0) | (24.9) | (28.4) | | | (527.1) | (27) | (4.4) | (31.3) | | | (97.3) | (151.2) |
| August | 33.2 | 24.5 | 28.8 | 36.9 | 22.2 | 365.6 | 17 | 7.1 | 32.6 | ? | ? | 95.5 | 179.0 |
| | (32.2) | (24.8) | (28.5) | | | (434.0) | (25) | (4.9) | (31.4) | | | (103.9) | (150.2) |
| September | 31.4 | 23.4 | 27.4 | 33.9 | 21.6 | 385.8 | 18 | 5.2 | 31.2 | ? | ? | 76.5 | 137.7 |
| | (32.3) | (24.4) | (28.4) | | | (331.7) | (18) | (5.8) | (31.2) | | | (101.7) | (147.5) |
| October | 31.9 | 22.3 | 27.1 | 34.4 | 20.2 | 72.8 | 7 | 6.9 | 29.0 | ? | ? | 79.4 | 132.5 |
| | (31.3) | (22.4) | (26.8) | | | (204.1) | (11) | (6.7) | (29.6) | | | (86.2) | (132.7) |
| November | 29.4 | 18.0 | 23.7 | 32.4 | ? | 59.7 | 7 | 7.8 | 26.2 | ? | ? | 61.7 | 102.8 |
| | (29.2) | (17.4) | (23.3) | | | (37.0) | (3) | (7.7) | (26.1) | | | (68.7) | (100.6) |
| December | 27.5 | ? | ? | 30.4 | ? | 9.0 | 0 | 8.8 | 22.3 | ? | ? | 62.1 | ? |
| | (26.7) | (12.4) | (19.6) | | | (10.6) | (1) | (8.0) | (22.5) | | | (60.1) | (78.9) |

## PER CENT RELATIVE HUMIDITY

### Table 2(a). Silcoorie

| Hours IST | Jan. | Feb. | March | April | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0619 | 95 | 93 | 91 | 91 | 95 | 96 | 96 | 94 | 96 | 94 | 96 | 94 |
| | (98) | (97) | (94) | (91) | (91) | (95) | (96) | (96) | (95) | (96) | (97) | (98) |
| 1319 | 49 | 38 | 35 | 54 | 71 | 80 | 75 | 67 | 73 | 66 | 59 | 45 |
| | (47) | (43) | (44) | (58) | (68) | (76) | (76) | (74) | (71) | (68) | (57) | (50) |

Note : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open pan water surface.
(iv) ? indicates data not available.

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1978

### Table 3. Nagrakata (Doors), West Bengal

Latitude 26°54′ N  Longitude 88°55′ E  Altitude 228.6 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 21.9 (23.6) | 10.4 (10.5) | 16.2 (17.0) | 24.3 | 6.6 | 5.4 (11.5) | 4 (2) | 7.3 (7.6) | 17.2 (18.2) | 17.9 (19.0) | 18.8 (19.6) | 58.1 (75.4) | 68.4 (70.2) |
| February | 24.7 (25.4) | 12.1 (12.8) | 18.4 (19.1) | 31.7 | 8.5 | 4.8 (25.4) | 2 (3) | 7.4 (7.4) | 19.4 (20.2) | 19.8 (20.0) | 20.2 (20.6) | 77.1 (93.8) | 91.5 (93.5) |
| March | 29.6 (29.5) | 15.2 (16.4) | 22.4 (23.0) | 32.7 | 11.2 | 23.2 (37.3) | 5 (5) | 8.2 (7.7) | 23.6 (24.9) | 23.0 (23.8) | 23.4 (23.8) | 146.3 (158.3) | 146.6 144.3 |
| April | 31.4 (30.9) | 19.6 (20.0) | 25.5 (25.4) | 35.3 | 15.7 | 117.3 (143.9) | 12 (11) | 7.7 (6.9) | 27.4 (27.0) | 27.0 (27.0) | 26.2 (26.6) | 168.4 (160.3) | 168.4 (161.6) |
| May | 30.4 (30.6) | 22.2 (21.6) | 26.3 (26.1) | 35.9 | 19.9 | 427.6 (367.3) | 23 (20) | 4.8 (6.5) | 27.4 (28.2) | 28.4 (27.6) | 28.2 (27.8) | 124.0 (153.3) | 151.5 (173.7) |
| June | 31.3 (30.3) | 23.8 (23.3) | 27.6 (26.8) | 33.9 | 20.8 | 1008.8 (882.7) | 27 (26) | 4.2 (3.9) | 29.1 (28.5) | 28.8 (28.0) | 29.4 (28.3) | 105.0 (109.3) | 145.0 (137.2) |
| July | 30.6 (30.4) | 24.0 (23.8) | 27.3 (27.1) | 34.5 | 22.3 | 753.8 (1041.9) | 27 (27) | 3.9 (3.4) | 28.4 (28.8) | 29.2 (28.3) | 29.0 (28.8) | 112.7 (107.0) | 142.6 (134.8) |
| August | 32.5 (30.7) | 24.4 (23.7) | 28.4 (27.2) | 36.7 | 22.1 | 353.6 (775.9) | 17 (27) | 5.7 (4.1) | 30.6 (29.0) | 31.4 (28.6) | 30.3 (28.8) | 128.3 (106.7) | 162.0 (136.6) |
| September | 30.7 (30.6) | 23.3 (22.8) | 27.0 (26.7) | 33.6 | 21.6 | 499.7 (554.3) | 21 (21) | 4.5 (5.1) | 29.0 (28.8) | 31.6 (28.6) | 29.4 (28.7) | 85.0 (106.3) | 124.6 (130.1) |
| October | 30.7 (29.8) | 20.2 (19.6) | 25.4 (24.7) | 32.6 | 17.1 | 103.1 (221.5) | 7 (11) | 8.1 (7.7) | 27.7 (26.8) | 30.4 (27.2) | 28.3 (27.3) | 101.8 (107.3) | 148.2 (130.1) |
| November | 26.1 (27.4) | 16.7 (14.8) | 21.4 (21.1) | 29.9 | 11.4 | 150.2 (19.9) | 10 (3) | 6.2 (8.5) | 23.5 (22.8) | 23.6 (23.2) | 24.8 (24.2) | 63.9 (85.2) | 84.8 (95.4) |
| December | 25.0 (24.8) | 11.4 (11.6) | 18.2 (18.2) | 27.6 | 9.7 | 0.2 (4.4) | 1 (1) | 9.0 (8.3) | 19.0 (19.5) | 19.2 (19.9) | 20.8 (21.1) | 61.1 (73.9) | 75.5 (72.5) |

## PER CENT RELATIVE HUMIDITY

### Table 3(a). Nagrakat (Dooars), West Bengal

| Hours IST | Jan. | Feb. | March | April | May | June | July | August | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0634 | 86 (85) | 82 (81) | 72 (74) | 74 (77) | 90 (88) | 94 (95) | 94 (96) | 91 (95) | 95 (95) | 87 (89) | 92 (85) | 87 (86) |
| 1334 | 52 (51) | 46 (48) | 34 (43) | 48 (54) | 70 (69) | 74 (82) | 78 (83) | 74 (81) | 80 (77) | 61 (67) | 63 (57) | 50 (53) |

Notes : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open pan water surface.

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1978

**Table. 4. Nagri Farm (Darjeeling), West Bengal**

Latitude 26°55′ N Longitude 88°12′ E Altitude 1158.2 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 13.4 | 6.7 | 10.0 | 16.3 | 3.9 | 19.7 | 5 | 5.0 | 11.1 | 10.2 | 12.5 | 35.3 | 50.9 |
| | (15.0) | (7.8) | (11.4) | | | (18.7) | (3) | (6.0) | (13.1) | (12.1) | (14.0) | (43.8) | (56.3) |
| February | 16.2 | 8.8 | 12.5 | 23.3 | 6.5 | 17.0 | 5 | 5.7 | 13.6 | 12.0 | 13.6 | 47.7 | 67.9 |
| | (16.8) | (9.5) | (13.2) | | | (19.9) | (4) | (5.9) | (14.4) | (13.3) | (14.5) | (54.0) | (74.4) |
| March | 21.8 | 12.2 | 17.0 | 24.6 | 7.0 | 86.4 | 3 | 8.0 | 17.4 | 16.0 | 17.2 | 105.4 | 124.2 |
| | (21.5) | (13.2) | (17.4) | | | (47.3) | (4) | (6.9) | (19.3) | (17.2) | (17.8) | (109.7) | (129.7) |
| April | 23.5 | 15.7 | 19.6 | 27.1 | 12.1 | 22.7 | 7 | 6.7 | 20.8 | 18.4 | 19.0 | 98.2 | 137.8 |
| | (23.5) | (15.8) | (19.6) | | | (106.5) | (11) | (5.6) | (21.8) | (20.0) | (20.4) | (107.7) | (132.5) |
| May | 23.7 | 17.0 | 20.4 | 28.5 | 14.6 | 240.8 | 19 | 3.4 | 23.2 | 21.6 | 22.2 | 68.2 | 119.4 |
| | (23.8) | (17.0) | (20.4) | | | (196.3) | (20) | (5.1) | (23.4) | (21.7) | (22.0) | (81.7) | (135.8) |
| June | 24.2 | 18.9 | 21.6 | 26.1 | 16.7 | 426.8 | 24 | 2.6 | 24.8 | 23.0 | 23.8 | 56.5 | 112.3 |
| | (24.0) | (18.7) | (21.4) | | | (431.4) | (25) | (2.9) | (24.4) | (22.9) | (23.2) | (59.3) | (117.1) |
| July | 24.1 | 19.0 | 21.6 | 27.6 | 17.8 | 467.6 | 29 | 2.9 | 24.8 | 23.1 | 24.0 | 59.7 | 116.5 |
| | (24.3) | (19.3) | (21.8) | | | (646.6) | (27) | (2.4) | (24.8) | (23.3) | (23.8) | (61.3) | (113.0) |
| August | 25.9 | 20.0 | 23.0 | 30.8 | 18.0 | 343.8 | 19 | 5.7 | 26.3 | 24.6 | 25.6 | 97.5 | 137.0 |
| | (24.7) | (19.1) | (21.8) | | | (474.6) | (25) | (3.2) | (25.2) | (23.6) | (24.2) | (65.8) | (113.5) |
| September | 23.8 | 18.4 | 21.1 | 26.7 | 17.0 | 277.0 | 22 | 3.3 | 24.8 | 23.1 | 24.4 | 102.9 | 100.0 |
| | (24.4) | (18.2) | (21.3) | | | (325.1) | (20) | (3.9) | (24.3) | (22.8) | (23.7) | (60.6) | (104.9) |
| October | 23.4 | 16.6 | 20.0 | 25.7 | 14.0 | 34.0 | 7 | 7.3 | 23.1 | 21.6 | 23.8 | 79.7 | 110.8 |
| | (23.2) | (15.7) | (19.4) | | | (129.2) | (8) | (6.5) | (22.2) | (20.8) | (22.0) | (69.2) | (105.7) |
| November | 18.9 | 12.1 | 15.5 | 24.0 | 8.4 | 14.9 | 8 | 4.8 | 17.9 | 17.5 | 18.8 | 42.4 | 64.4 |
| | (20.5) | (12.0) | (16.2) | | | (12.1) | (2) | (7.1) | (18.2) | (17.1) | (18.8) | (56.9) | (77.0) |
| December | 18.0 | 10.1 | 14.0 | 22.5 | 7.6 | 1.6 | 2 | 8.4 | 15.6 | 14.2 | 15.2 | 56.4 | 64.9 |
| | (17.4) | (9.2) | (13.3) | | | (5.1) | (1) | (6.7) | (14.6) | (13.6) | (15.6) | (48.4) | (57.9) |

## PER CENT RELATIVE HUMIDITY

**Table 4(a). Nagri Farm (Darjeeling), West Bengal**

| Hours IST | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0637 | 71 | 75 | 58 | 68 | 84 | 92 | 92 | 85 | 89 | 70 | 79 | 60 |
| | (71) | (70) | (62) | (69) | (82) | (92) | (94) | (93) | (89) | (77) | (68) | (69) |
| 1337 | 71 | 73 | 59 | 67 | 82 | 87 | 87 | 78 | 82 | 72 | 77 | 59 |
| | (72) | (65) | (57) | (67) | (83) | (89) | (89) | (86) | (86) | (79) | (71) | (70) |

Notes : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open pan water surface.

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1978

### Thakurbari (North Bank of Brahmaputra), Assam

**Table 5.**

Latitude 26°43'35" N Longitude 92°42'35" E Altitude 92.45 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 23.5 | 6.9 | 15.2 | 26.2 | 3.8 | 0.0 | 0 | 7.8 | ? | ? | ? | 49.0 | 62.1 |
| | (23.9) | (8.8) | (16.4) | | | (20.4) | (4) | (7.6) | | | | (52.6) | (61.9) |
| February | 25.6 | 10.2 | 17.9 | 31.2 | 6.4 | 1.8 | 2 | 7.3 | ? | ? | ? | 64.2 | 97.7 |
| | (26.4) | (11.8) | (19.1) | | | (12.6) | (3) | (7.1) | | | | (70.2) | (188.9) |
| March | 30.5 | 16.2 | 23.4 | 33.4 | 12.1 | 53.1 | 5 | 8.9 | ? | ? | ? | 133.1 | (153.6) |
| | (30.2) | (15.1) | (22.8) | | | (46.9) | (5) | (7.7) | | | | (119.6) | (138.8) |
| April | 31.3 | 20.6 | 26.0 | 35.5 | 16.7 | 41.3 | 9 | 8.2 | ? | ? | ? | 137.4 | 175.1 |
| | (30.1) | (19.3) | (24.7) | | | (214.3) | (15) | (6.2) | | | | (118.0) | (147.8) |
| May | 32.5 | 23.7 | 28.1 | 38.9 | 20.9 | 173.3 | 13 | 5.8 | ? | ? | ? | 139.5 | 169.4 |
| | (30.7) | (21.4) | (26.0) | | | (280.2) | (16) | (6.2) | | | | (116.7) | (162.7) |
| June | 32.0 | 25.0 | 28.5 | 35.6 | 22.0 | 558.6 | 23 | 4.5 | ? | ? | ? | 117.0 | 153.4 |
| | (31.4) | (23.8) | (27.6) | | | (439.0) | (23) | (4.2) | | | | (105.2) | (113.8) |
| July | 32.3 | 25.5 | 28.9 | 35.5 | 20.6 | 475.5 | 21 | 5.5 | ? | ? | ? | 121.8 | 167.8 |
| | (32.4) | (24.6) | (28.5) | | | (536.7) | (26) | (4.8) | | | | (112.8) | (157.0) |
| August | 33.5 | 26.2 | 29.8 | 36.8 | 23.1 | 169.6 | 14 | 6.2 | ? | ? | ? | 108.5 | 171.3 |
| | (32.1) | (24.5) | (28.4) | | | (332.2) | (20) | (5.4) | | | | (105.6) | (158.7) |
| September | 31.9 | 23.0 | 27.4 | 36.7 | 20.7 | 290.6 | 22 | 4.9 | ? | ? | ? | 78.3 | 130.3 |
| | (31.9) | (23.4) | (27.6) | | | (274.9) | (18) | (5.6) | | | | (85.8) | (137.5) |
| October | 31.5 | 19.8 | 25.6 | 34.4 | 15.5 | 63.1 | 4 | 7.7 | ? | ? | ? | 85.0 | 130.6 |
| | (30.4) | (20.4) | (25.4) | | | (176.1) | (11) | (6.8) | | | | (78.6) | (123.7) |
| November | 26.4 | 15.1 | 20.8 | 30.1 | 10.5 | 39.5 | 7 | 6.2 | ? | ? | ? | 50.2 | 81.0 |
| | (28.0) | (15.0) | (21.5) | | | (15.4) | (2) | (7.8) | ? | ? | ? | (53.0) | (88.3) |
| December | 25.6 | 7.7 | 16.6 | 27.4 | 5.0 | 00.0 | 0 | 9.2 | ? | ? | ? | 47.6 | 67.6 |
| | (24.6) | (9.7) | (17.2) | | | (18.8) | (4) | (7.9) | | | | (17.2) | (64.5) |

## PER CENT RELATIVE HUMIDITY

### Table 5(a). Thakurbari (North Bank), Assam

| Hours IST | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0619 | 90 | 89 | 81 | 81 | 85 | 92 | 89 | 89 | 96 | 94 | 95 | 95 |
| | (93) | (92) | (85) | (87) | (90) | (93) | (94) | (93) | (94) | (92) | (93) | (94) |
| 1319 | 38 | 44 | 40 | 48 | 60 | 76 | 75 | 71 | 76 | 66 | 67 | 55 |
| | (53) | (50) | (51) | (63) | (69) | (77) | (76) | (75) | (75) | (71) | (62) | (57) |

Notes : (i) Data in brackets show previous averages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open pan water surface.
(iv) ? indicates data not available.

## SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1978

**Table 6. Gungaram (Terai), West Bengal**

Latitude 26°47′ N Longitude 88°48′E Altitude 123.6 m (a.m.s.l.)

| Months 1978 | Daily temperature °C | | | | | Rainfall (mm) | | Daily sunshine hrs. | Daily Soil Temp. °C (under grass) | | | Monthly evaporation (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Max. | Mean Min. | Mean | Highest Max. | Lowest Min. | Monthly total | Rainy days | | Depth 5 cm | 15 cm | 30 cm | Open pan | Penman |
| January | 22.2 | 8.9 | 15.6 | 25.2 | 5.6 | 2.4 | 1 | 7.6 | 16.8 | 16.2 | 17.5 | 42.4 | 65.3 |
| | (22.7) | (9.1) | (15.9) | | | (1.4) | (1) | (7.6) | | | | (89.9) | (66.8) |
| February | 25.0 | 11.0 | 18.0 | 31.1 | 7.2 | 4.9 | 4 | 7.8 | 19.6 | 18.7 | 19.4 | 65.5 | 89.4 |
| | (25.8) | (11.1) | (18.4) | | | (3.5) | (2) | (8.0) | | | | (73.6) | ( 91.2) |
| March | 30.1 | 13.6 | 21.8 | 33.3 | 10.5 | 10.5 | 4 | 9.2 | 24.0 | 22.4 | 22.4 | 139.6 | 150.2 |
| | (31.1) | (15.2) | (23.2) | | | (22.5) | (3) | (9.0) | | | | (134.2) | (154.4) |
| April | 32.0 | 19.8 | 25.9 | 35.6 | 15.0 | 119.2 | 9 | 9.1 | 29.2 | 27.2 | 26.6 | 149.9 | 183.4 |
| | (30.4) | (20.0) | (25.2) | | | (105.8) | (10) | (8.0) | | | | (129.4) | (186.8) |
| May | 30.8 | 22.8 | 26.8 | 36.5 | 18.8 | 317.5 | 15 | 6.6 | 31.8 | 30.5 | 30.2 | 114.2 | 173.5 |
| | (30.2) | (21.8) | (26.0) | | | (310.4) | (17) | (7.0) | | | | (114.4) | (172.4) |
| June | 31.5 | 24.5 | 28.0 | 34.6 | 22.7 | 343.5 | 19 | 5.3 | 30.8 | 30.2 | 29.7 | 93.0 | 158.6 |
| | (30.8) | (22.8) | (26.8) | | | (356.3) | (21) | (5.1) | | | | (92.1) | (151.1) |
| July | 31.0 | 24.5 | 27.8 | 34.3 | 23.3 | 518.3 | 25 | 5.7 | 30.2 | 29.8 | 29.8 | 106.3 | 165.4 |
| | (30.9) | (24.7) | (27.8) | | | (652.9) | (24) | (5.2) | | | | (94.6) | (159.6) |
| August | 32.9 | 25.0 | 29.0 | 36.7 | 23.4 | 571.7 | 15 | 7.3 | 31.2 | 30.6 | 30.8 | 125.3 | 184.9 |
| | (32.0) | (24.9) | (28.4) | | | (688.4) | (20) | (6.4) | | | | (105.0) | (172.7) |
| September | 30.8 | 24.1 | 27.4 | 33.3 | 22.3 | 327.7 | 18 | 5.0 | 30.4 | 29.6 | 29.9 | 81.8 | 132.4 |
| | (31.2) | (24.1) | (27.6) | | | (343.1) | (16) | (5.8) | | | | (84.1) | (140.2) |
| October | 31.2 | 20.2 | 25.7 | 32.7 | 16.7 | 27.3 | 3 | 8.3 | 28.8 | 27.8 | 28.2 | 85.2 | 137.1 |
| | (30.0) | (20.0) | (25.0) | | | (109.0) | (6) | (7.8) | | | | (78.9) | (130.2) |
| November | 27.5 | 15.8 | 21.6 | 30.8 | 9.9 | 2.4 | 1 | 7.4 | 24.2 | 24.2 | 25.0 | 56.4 | 89.6 |
| | (27.4) | (16.1) | (21.8) | | | (47.2) | (4) | (7.4) | | | | (56.0) | (90.2) |
| December | 26.0 | 10.0 | 18.0 | 28.3 | 8.1 | 0.0 | 0 | 8.3 | 19.6 | 18.9 | 19.6 | 48.5 | 71.0 |
| | (25.4) | (10.8) | (18.1) | | | (9.6) | (2) | (7.9) | | | | (15.1) | (70.2) |

## PER CENT RELATIVE HUMIDITY

**Table 6(a). Gungaram (Terai), West Bengal**

| Hours IST | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0635 | 95 | 93 | 89 | 81 | 87 | 91 | 93 | 92 | 92 | 92 | 94 | 95 |
| | (94) | (92) | (84) | (85) | (88) | (91) | (92) | (92) | (92) | (94) | (94) | (95) |
| 1335 | 49 | 42 | 31 | 44 | 64 | 71 | 75 | 70 | 74 | 59 | 57 | 42 |
| | (48) | (41) | (34) | (53) | (64) | (74) | (77) | (74) | (72) | (62) | (58) | (47) |

Notes : (i) Data in brackets show previous everages.
(ii) Soil temp. at different depths are the mean of morning and afternoon records.
(iii) Penman in mm means Penman estimation of evaporation from an open pan water surface.